The volitional brain in a coercive world of disinformation:

The neural processes underlying our susceptibility and resilience to disinformation

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DONDERS INSTITUTE
Neuroengineering

Herculano-Houzel 2009	**Human brain**
Brain mass	1508 g
Total number of neurons in brain	86 billion
Total number of non-neurons in brain	85 billion
Mass, cerebral cortex	1233 g
Neurons, cerebral cortex	16 billion
Relative size of the cerebral cortex	82% of brain mass
Relative number of neurons in cerebral cortex	19% of brain neurons
Mass, cerebellum	154 g
Neurons, cerebellum	69 billion
Relative size of the cerebellum	10% of brain mass

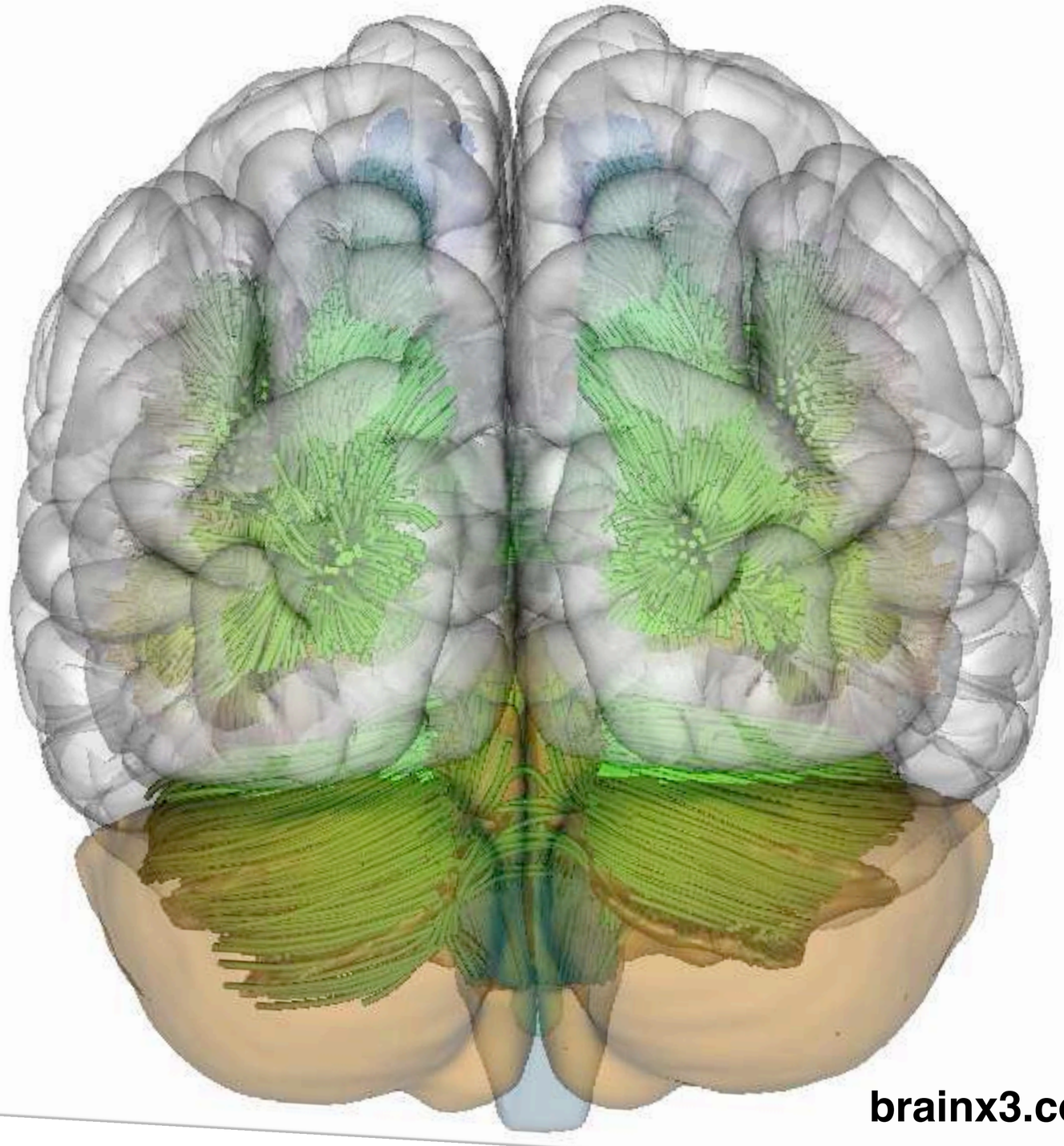
Myelinated fibers: 180K KM
Neocortex synapses: 0.15 10^15 (quadrillion)
Bee: 950K neurons
Neuron loss: 85K/day

Comparison brain weight:
Sperm whale: 7,800G
Fin whale: 6,930
Elephant: 4,783
Humpback whale: 4,675
Gray whale: 4,317

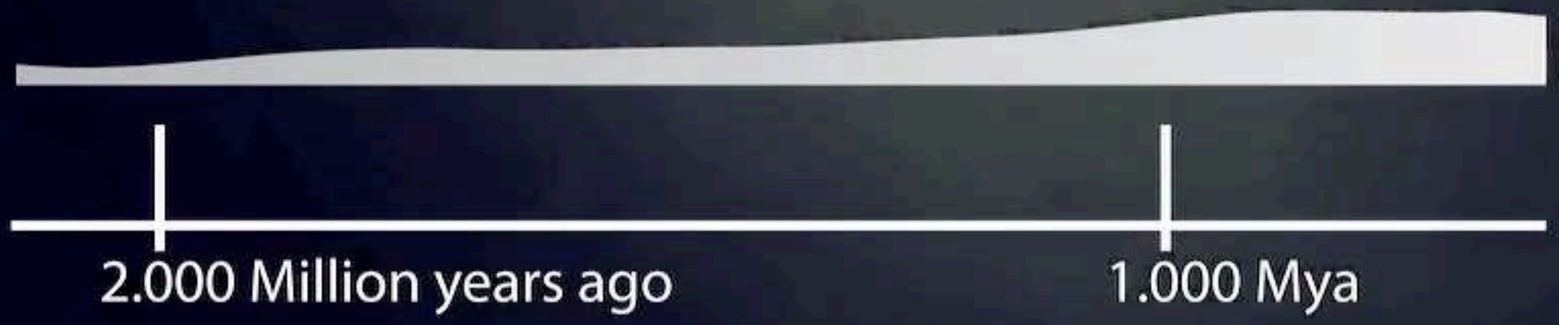
Power: 20W

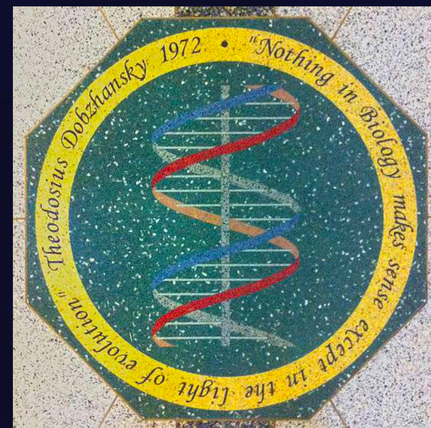
Pakkenberg et al., 1997; 2003

https://faculty.washington.edu/chudler/facts.html



brainx3.com

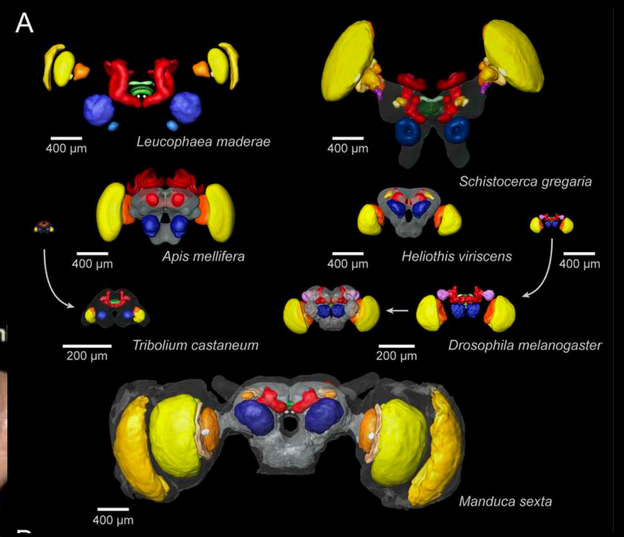

2.000 Million years ago
1.000 Mya

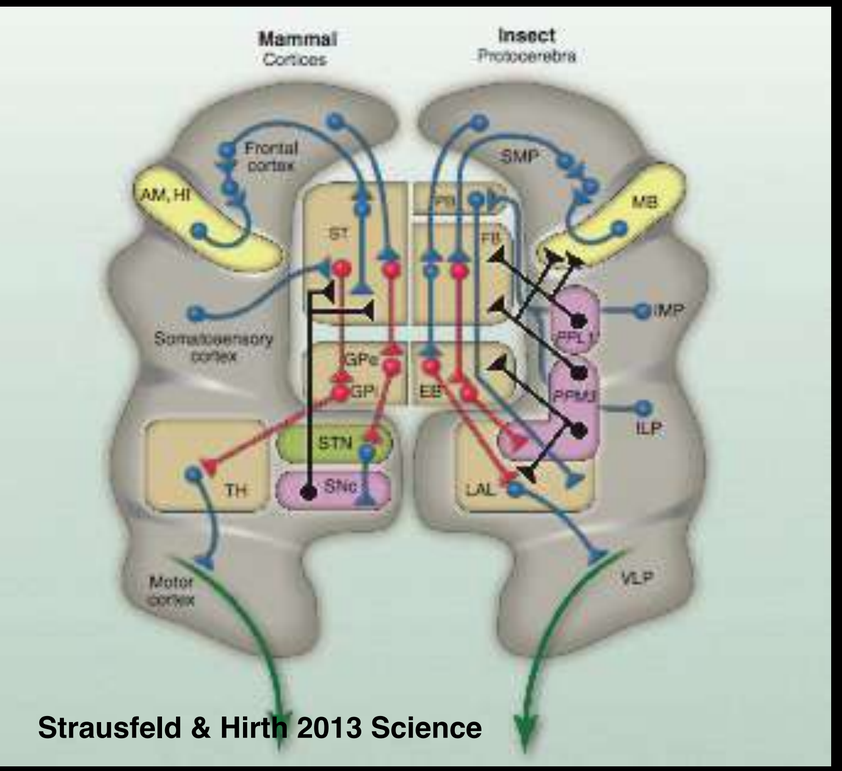

"Nothing in Biology makes sense except in the light of evolution" Theodosius Dobzhansky 1972

Brains share design common principles

Mammals

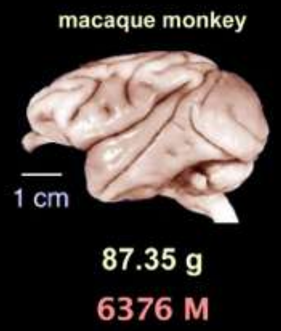
Insects

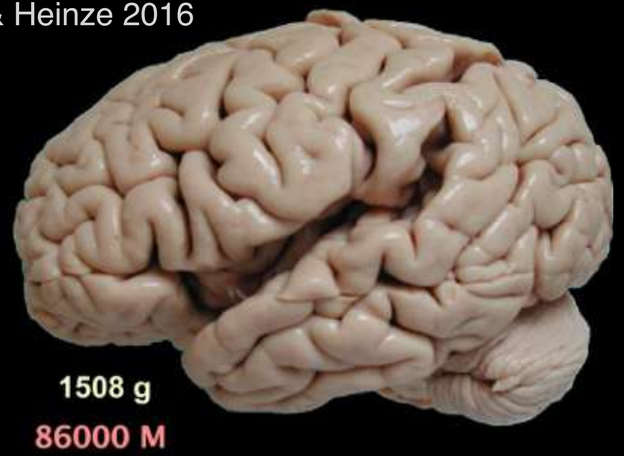




Strausfeld & Hirth 2013 Science

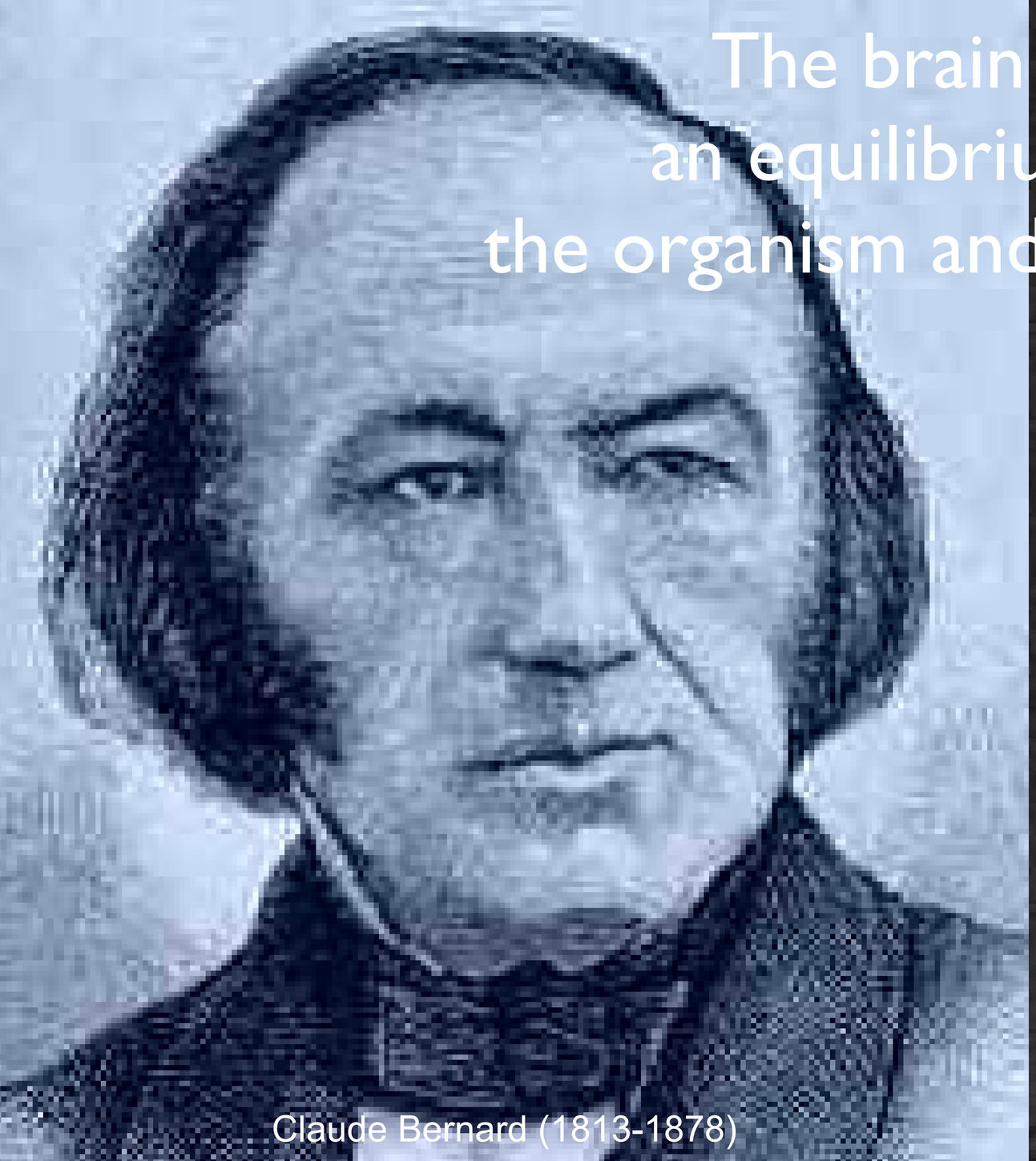
Basil el Jundi & Heinze 2016



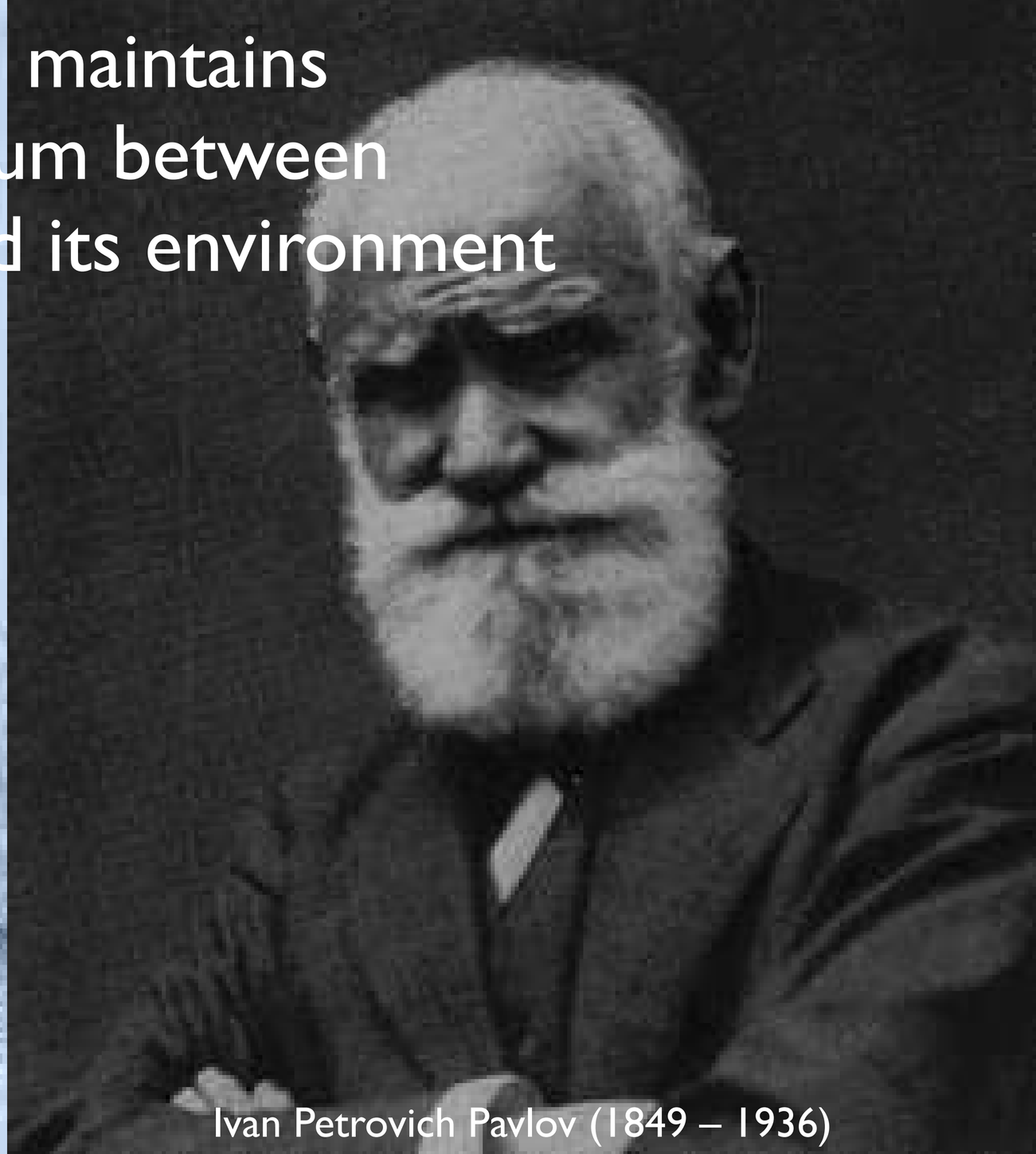


Herculano-Houzel 2009 Front Hum Neuro

The brain maintains
an equilibrium between
the organism and its environment



Claude Bernard (1813-1878)

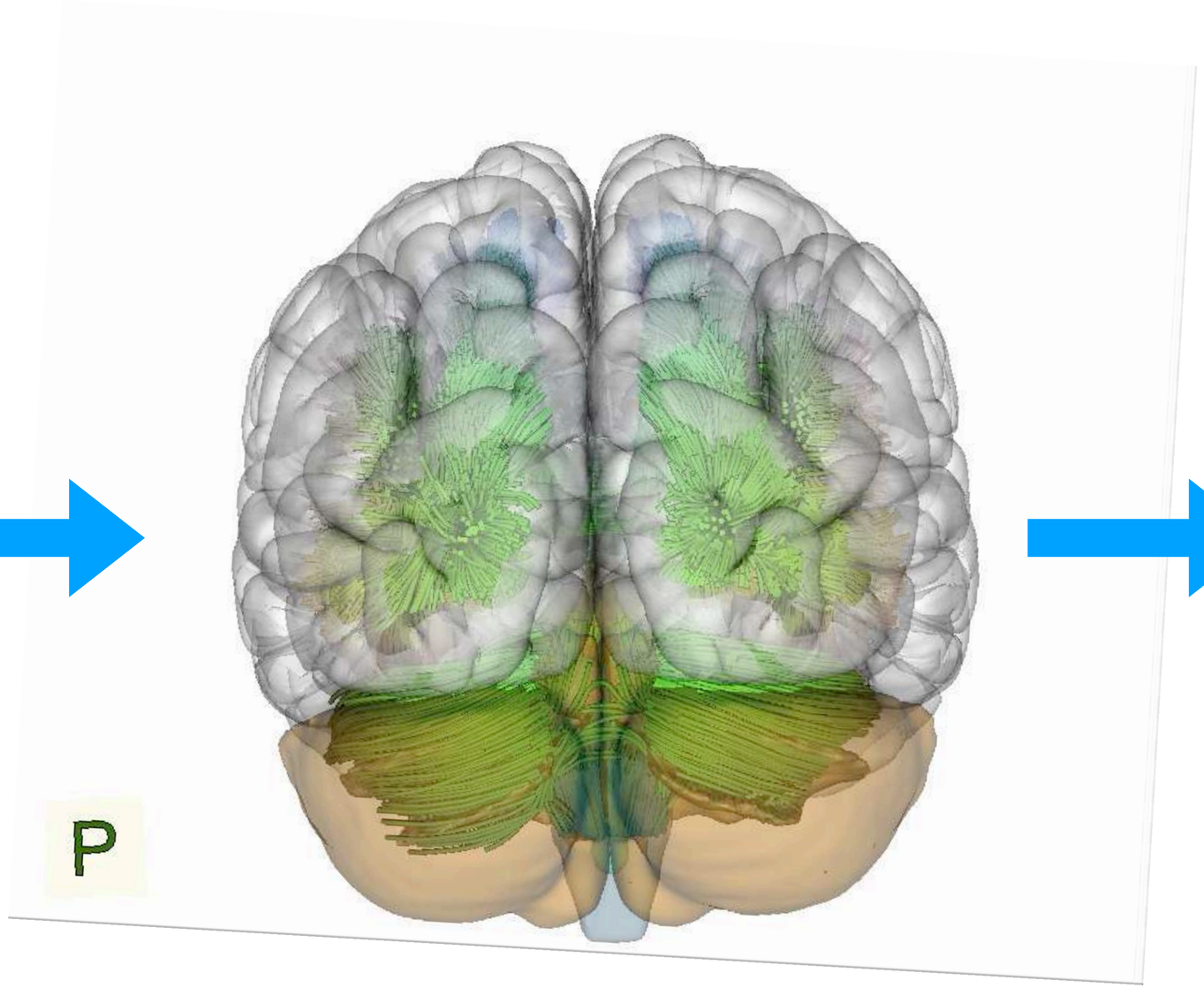


Ivan Petrovich Pavlov (1849 – 1936)


The embodied
brain controls
ACTION

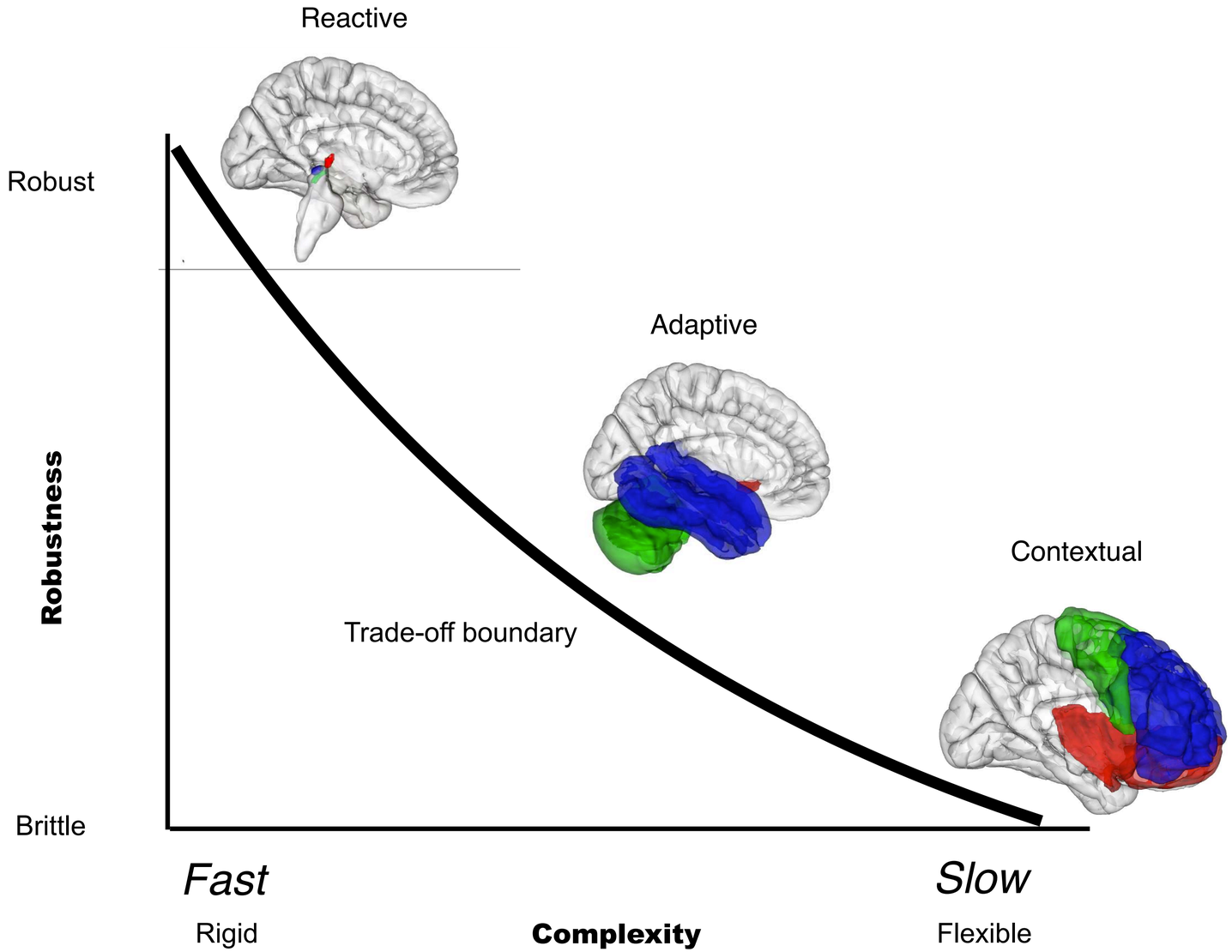
World

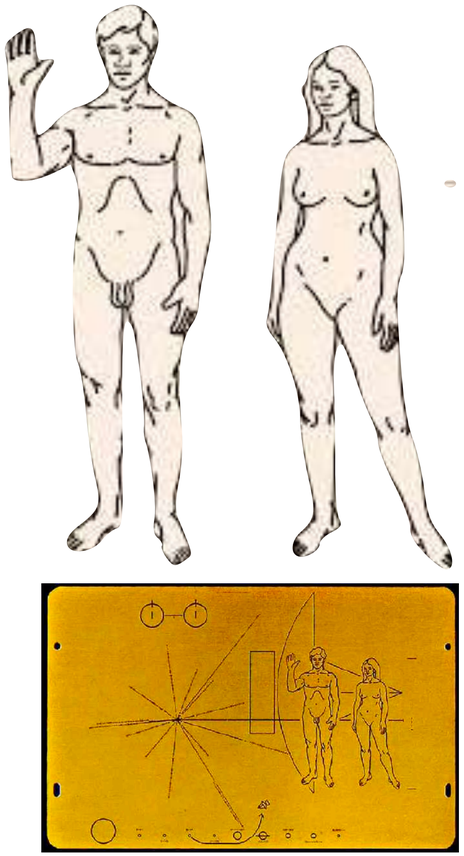
Body



Action

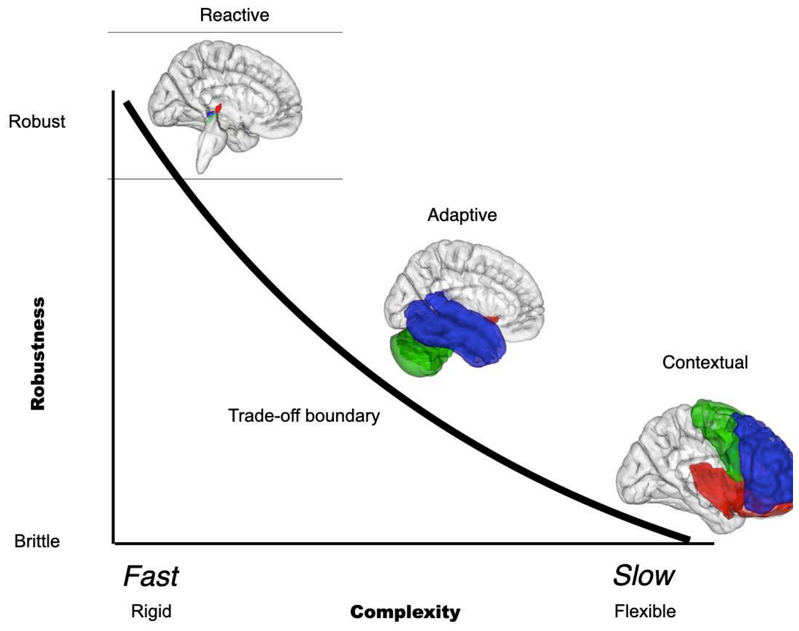
The embodied brain solves trade-offs

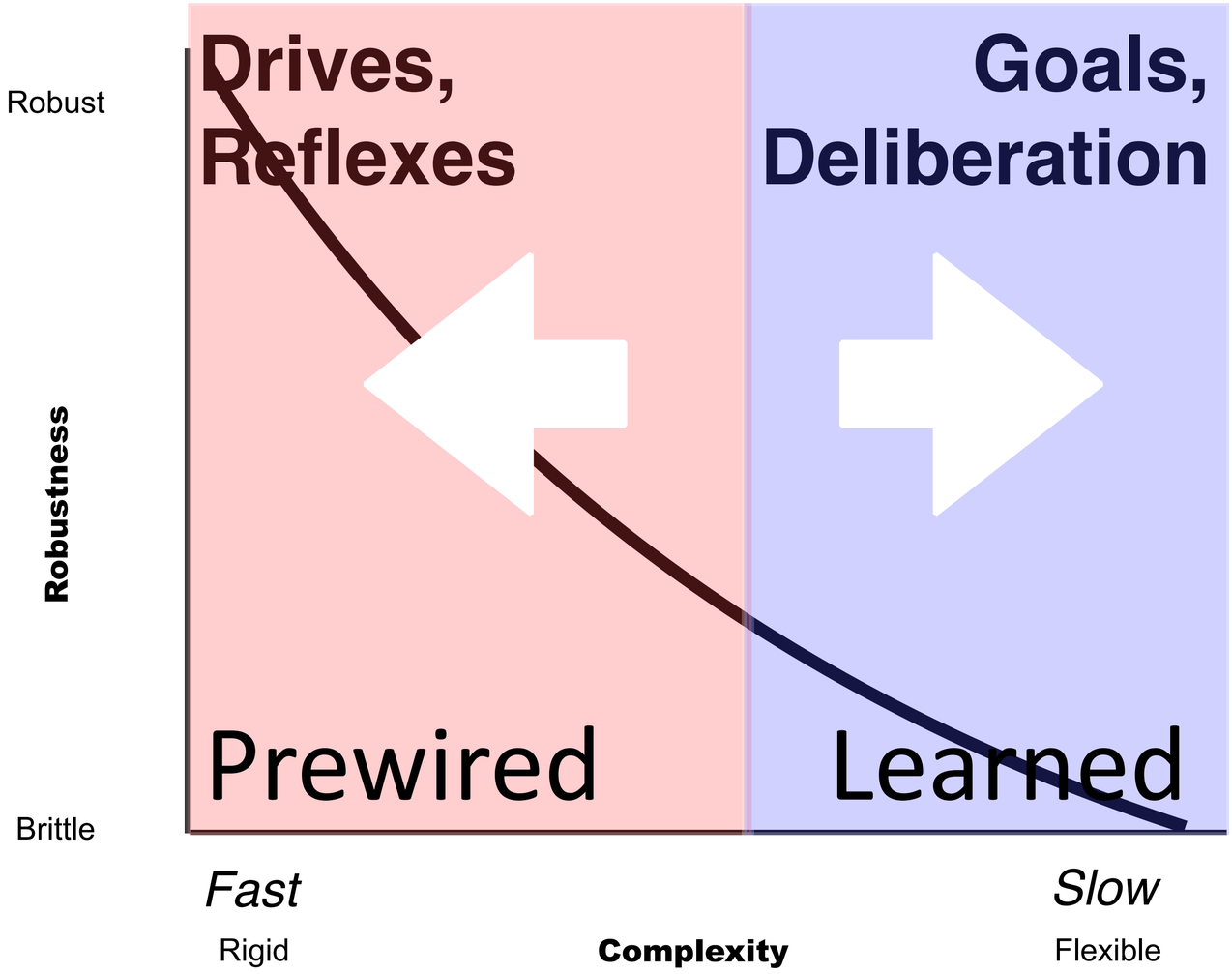




Verschure (1992) RAS; (2003) Nature; (2012) BICA; (2014; 2016) Phil.Tr.Roy.Soc B

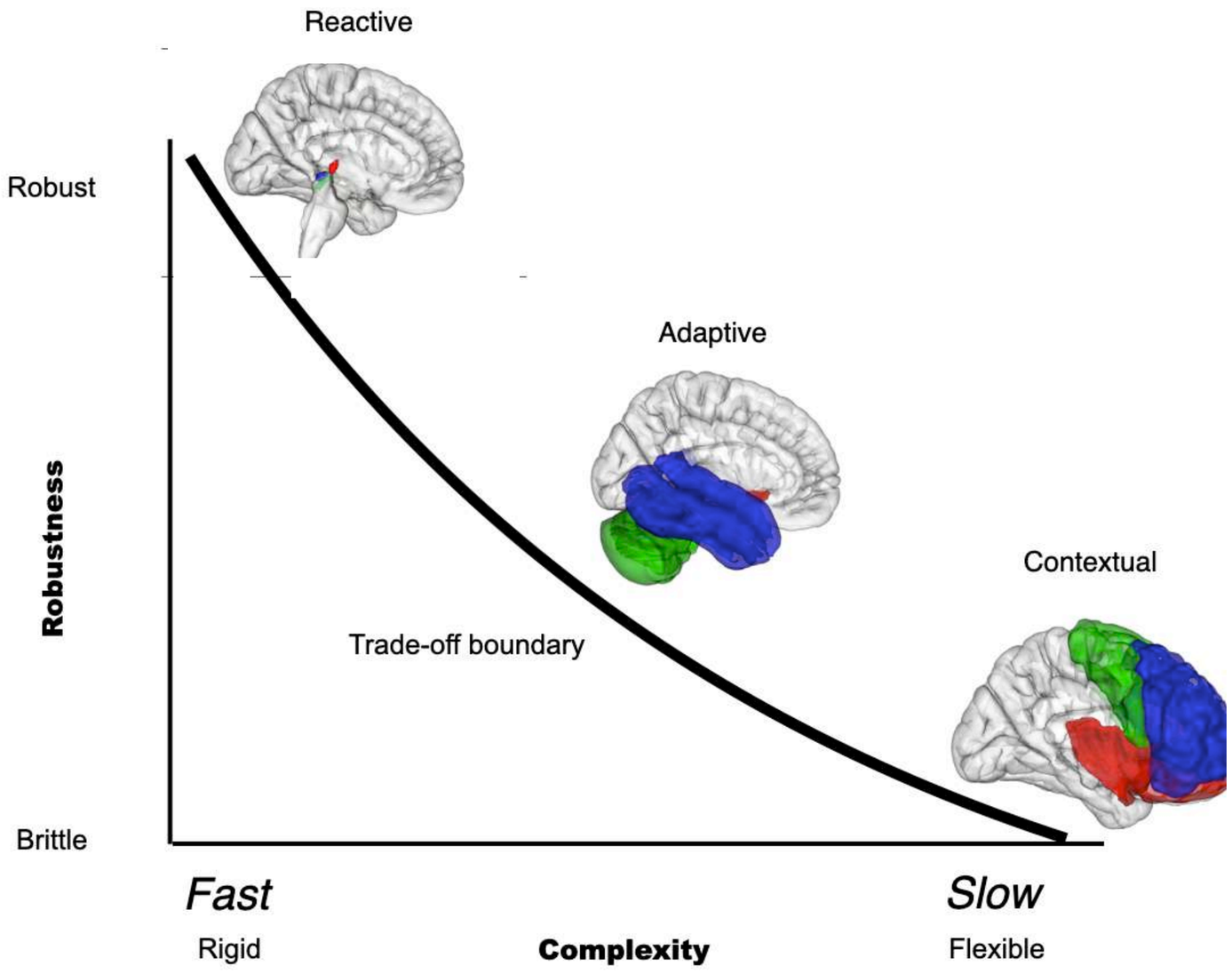
The embodied brain solves trade-offs

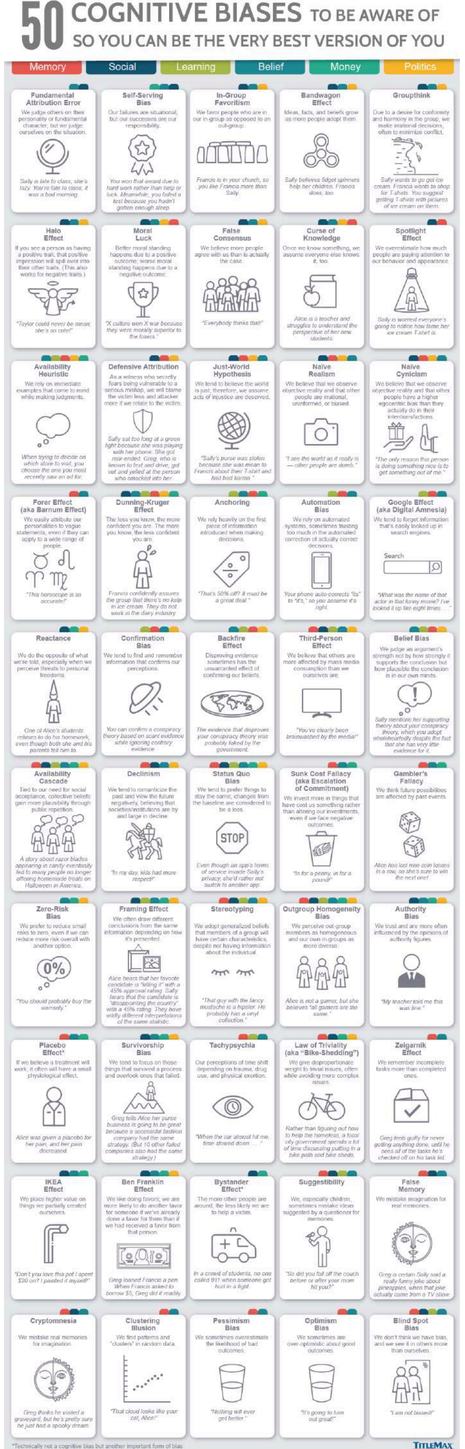


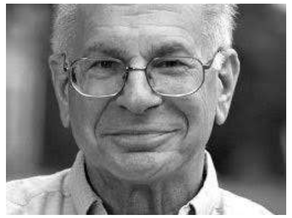


Verschure (1992) RAS; (2003) Nature; (2012) BICA; (2014; 2016) Phil.Tr.Roy.Soc B

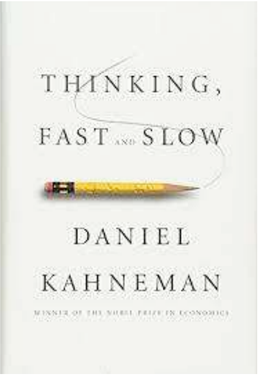
The brain fast and slow

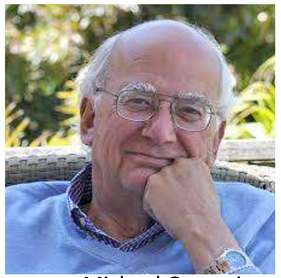




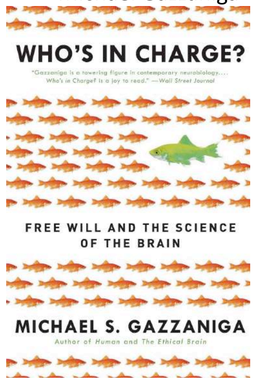


Daniel Kahneman





Michael Gazzaniga



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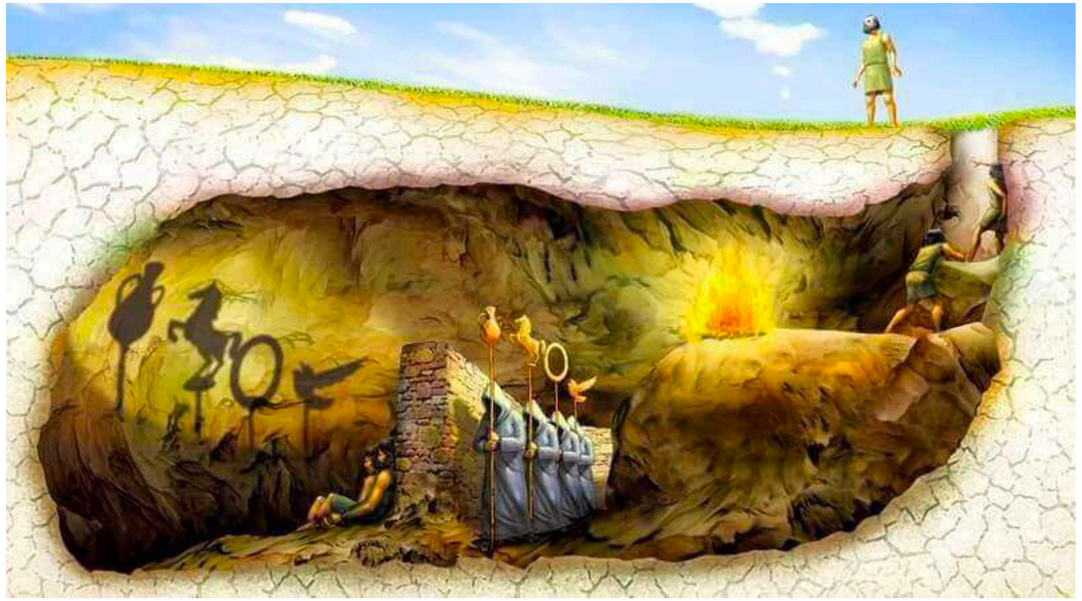
specs-lab.com

Paul Verschure

The Brain in Plato’s Cave



Plato, The Republic (514a–520a)

The knowledge problem

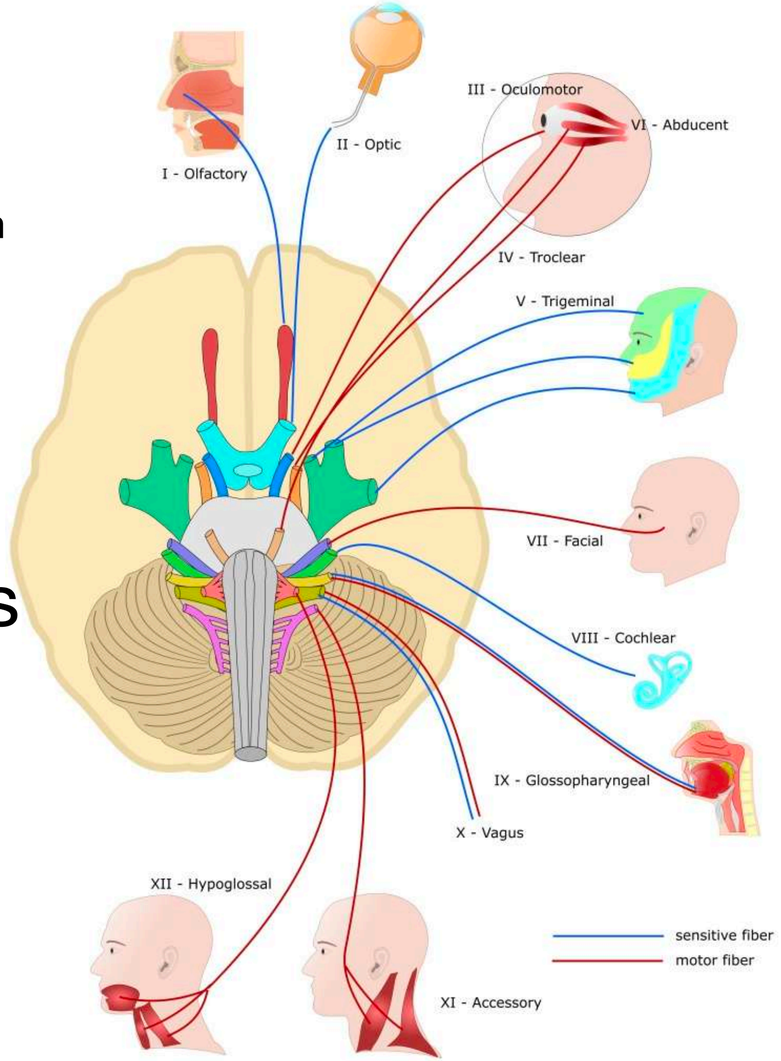
Plato

Aristotle

Hume

Descartes

Kant

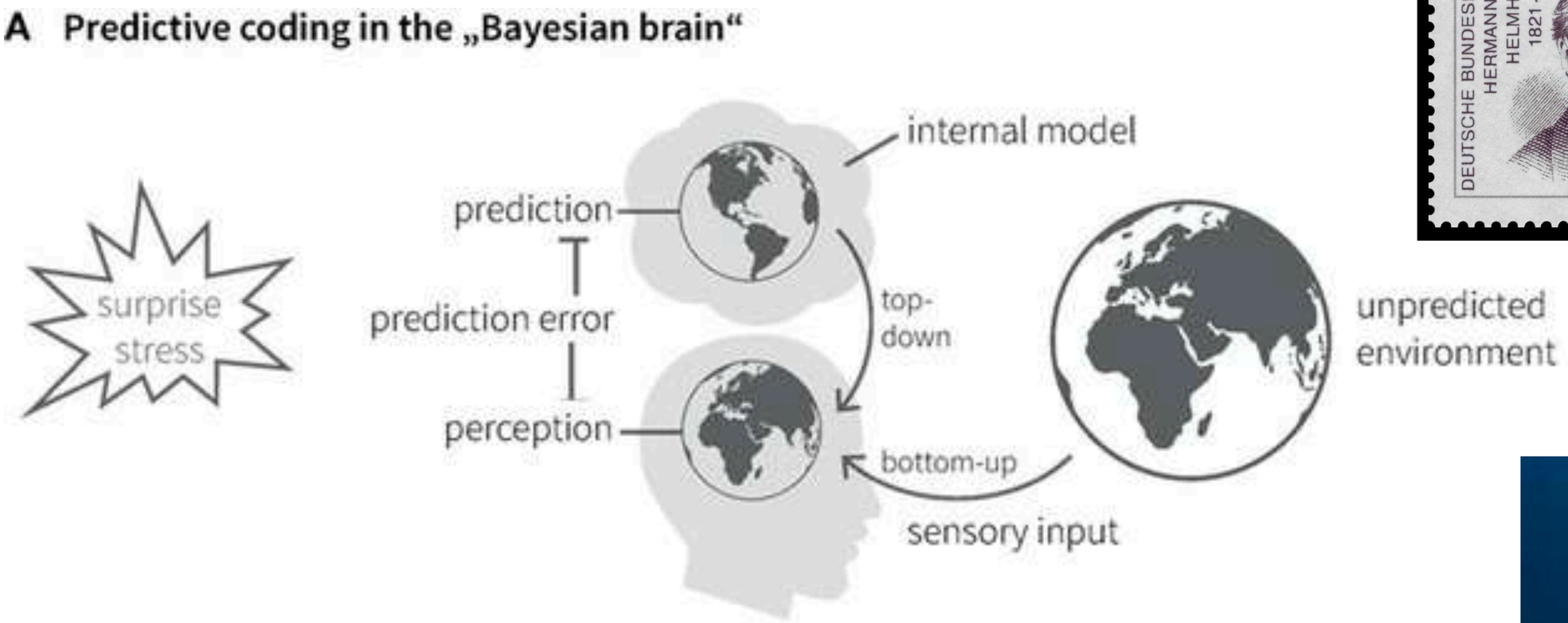


There is no direct access to information

The brain as a constructive empiricist

Bas van Fraasen

“Facts” are constructed by the brain



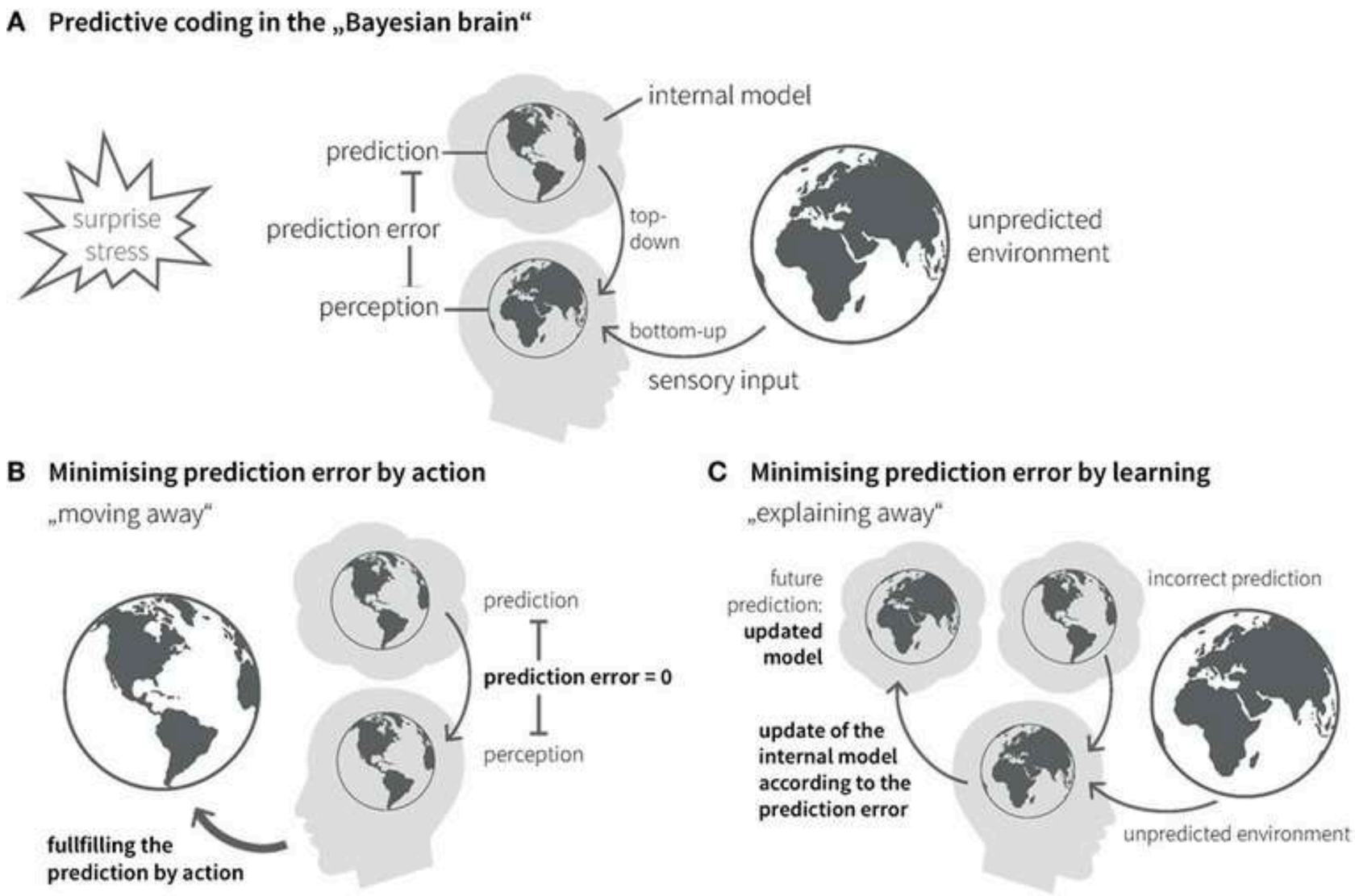
The Free Energy Principle

Friston 2010 Nat Rev Neurosci.

Karl Friston

Figure from: Haker et al 2016 Front. Psych

The brain as a constructive empiricist

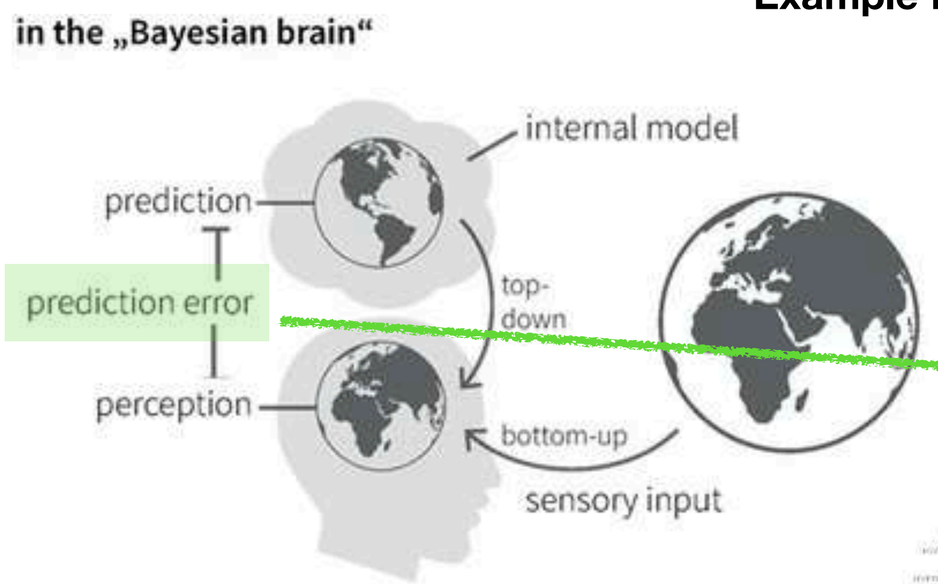


The Free Energy Principle Friston 2010 Nat Rev Neurosci.

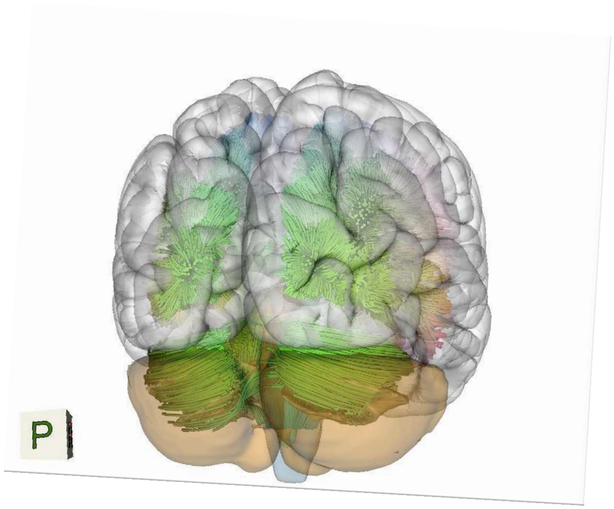
Figure from: Haker et al 2016 Front. Psych

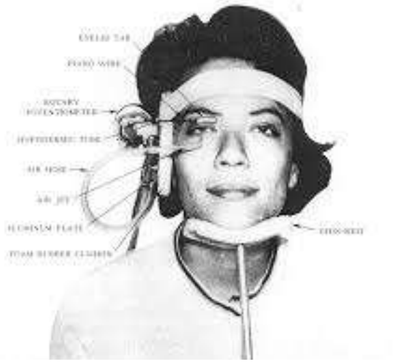
The brain is driven by surprise/error

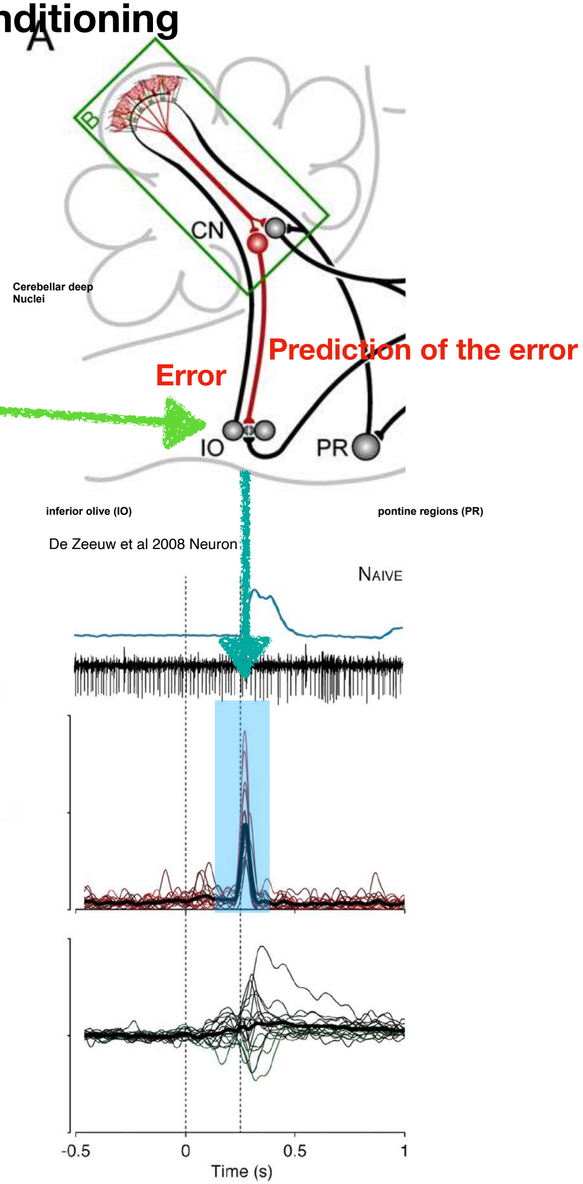
Example from classical conditioning



Haker et al 2016 Front. Psych







Ten Brinke et al 2015 Cell Reports

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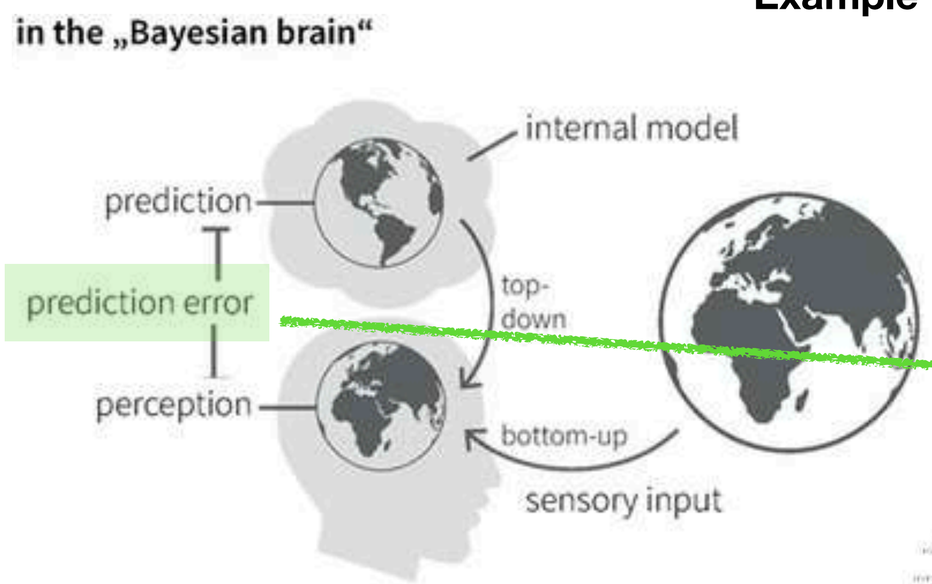
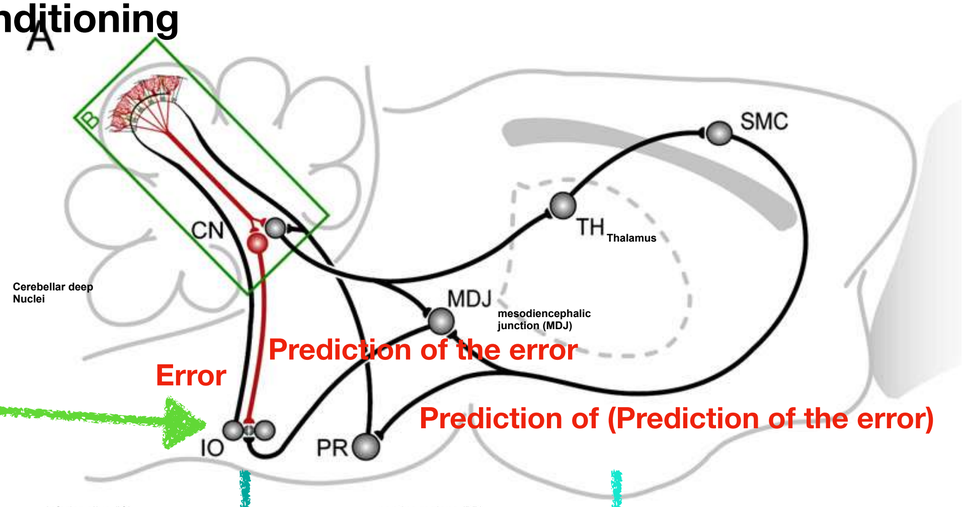
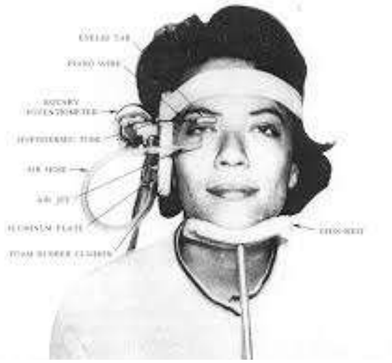
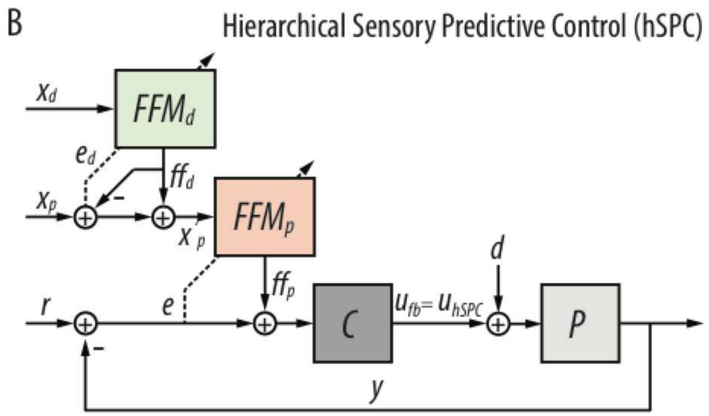
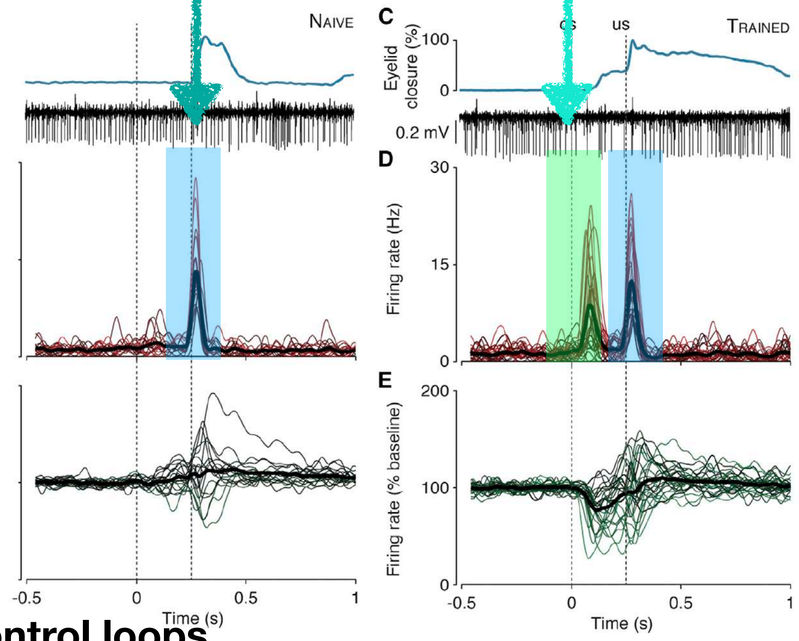




De Zeeuw et al 2008 Neuron





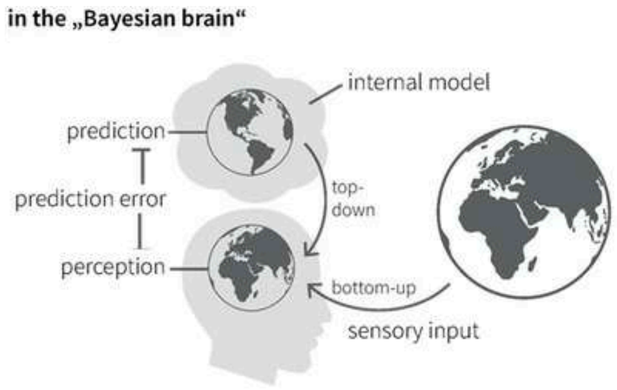


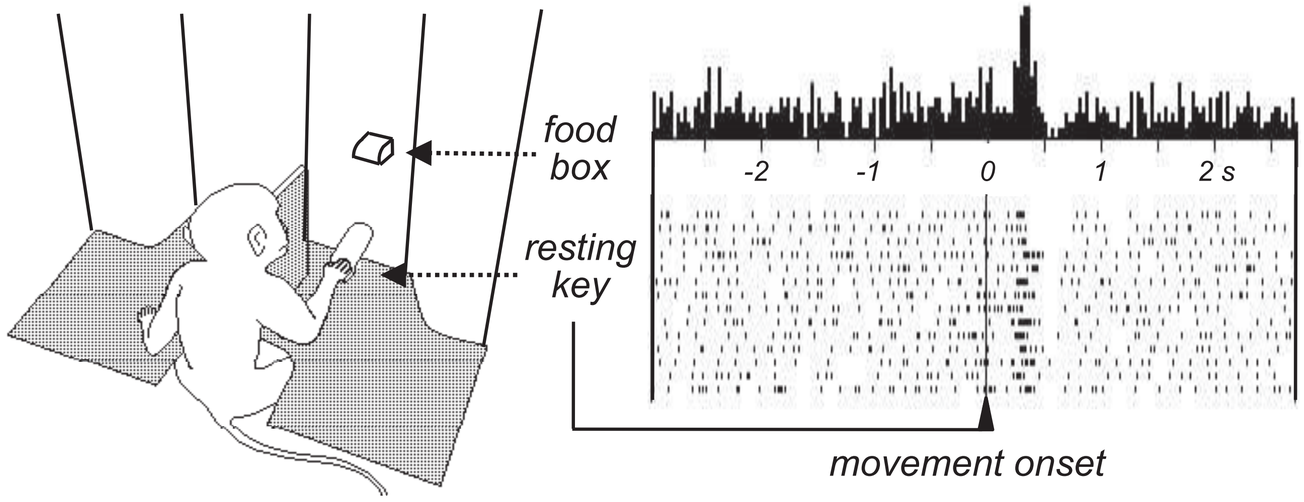
The cascading of multiple error driven control loops

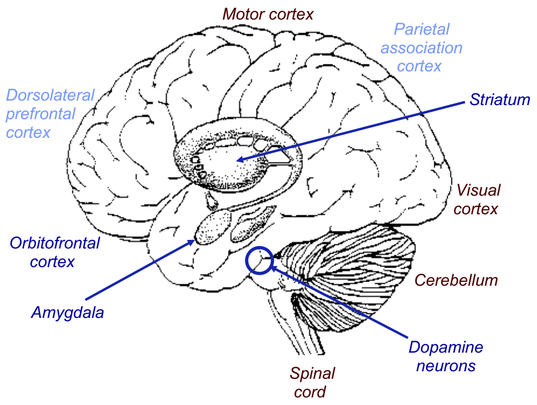
Maffei et al., 2017 Phil Tr Roy Soc B

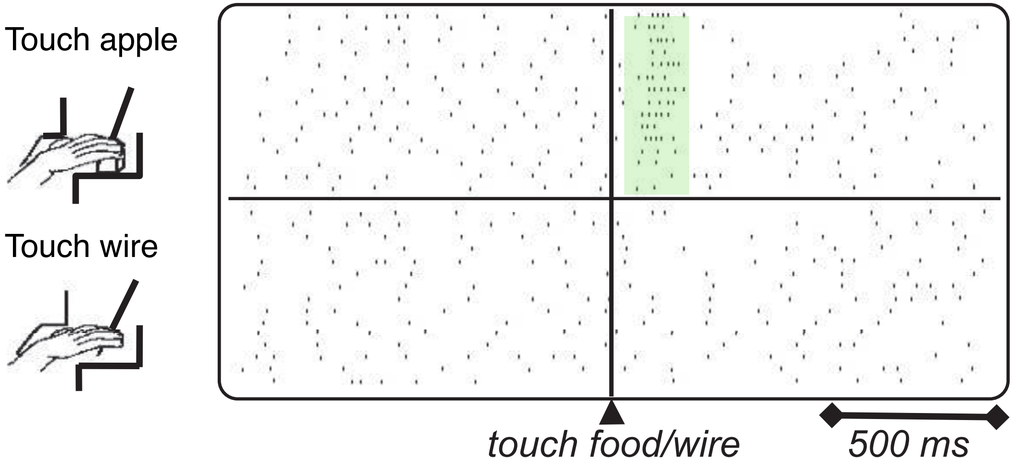
Ten Brinke et al 2015 Cell Reports

Dopamine and the **expectation** of reward









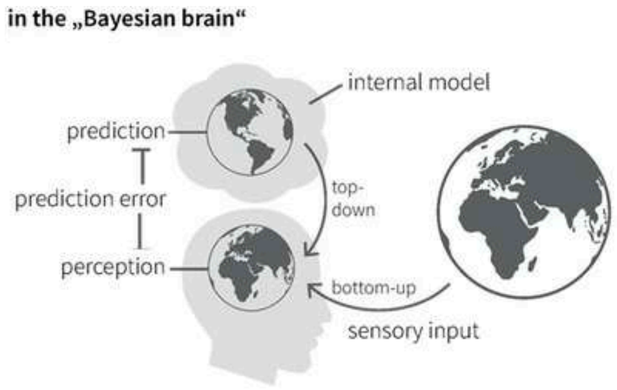
Schultz (2015) *Physiol Rev*

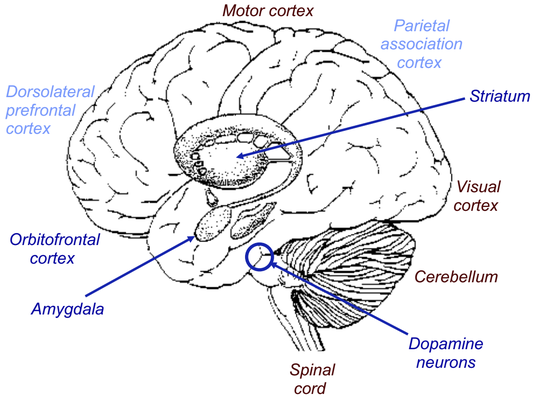
Monkeys like apples

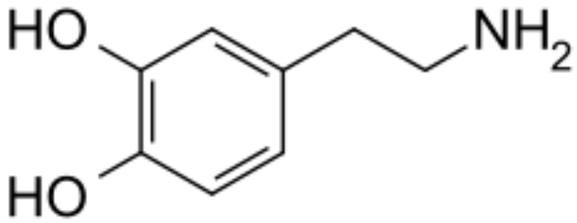
Paul Verschure

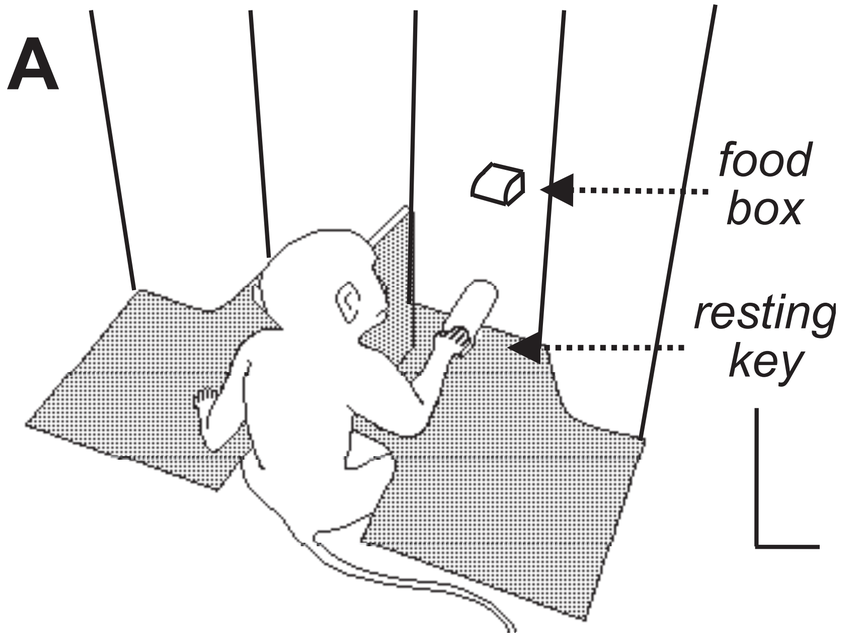
Dopamine and the **expectation** of reward

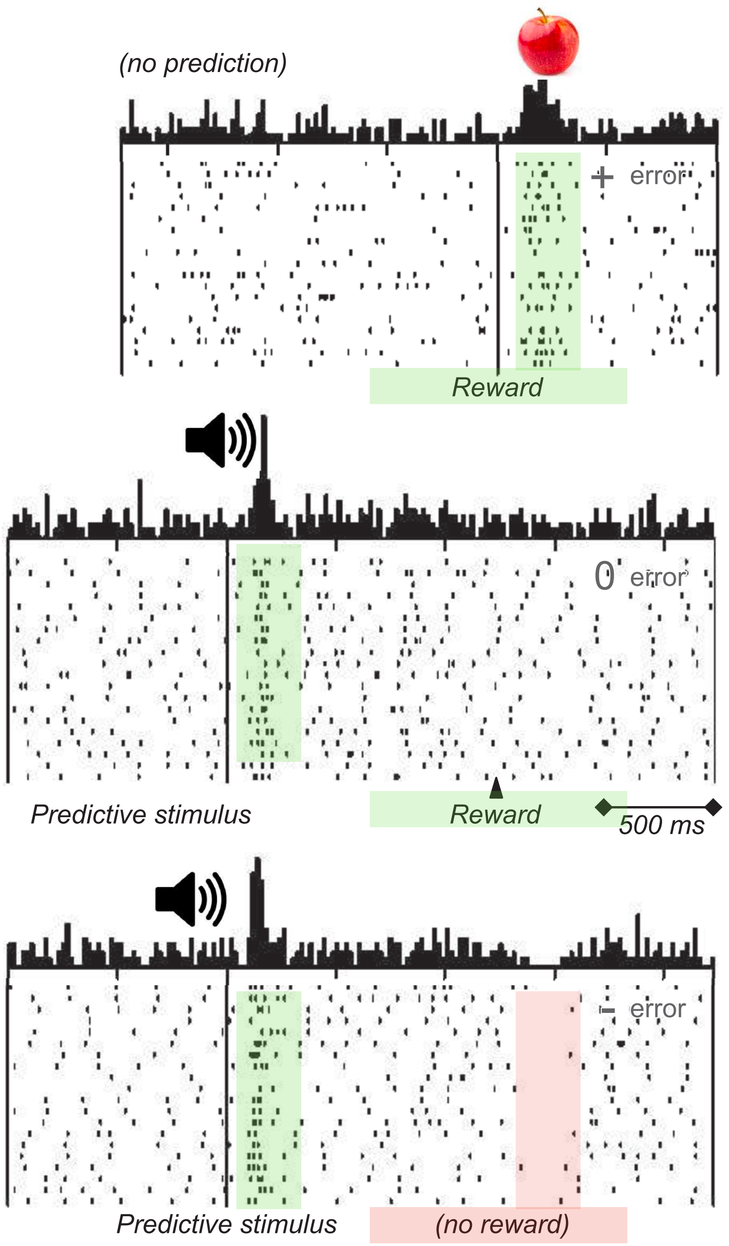
Touch apple











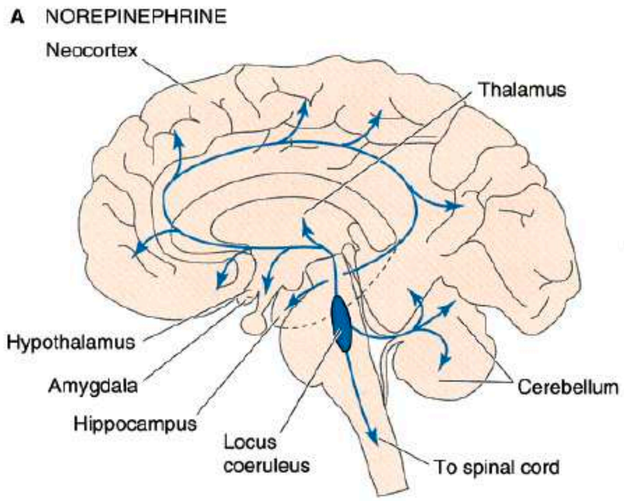
Schultz (2015) *Physiol Rev*

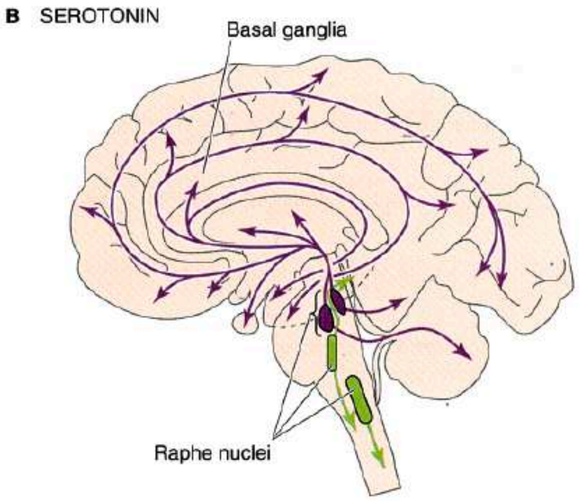
Monkeys like the prediction of apples

Paul Verschure

Arbitration, Regulation & (Neuro)Modulation to control action in a partially knowable world

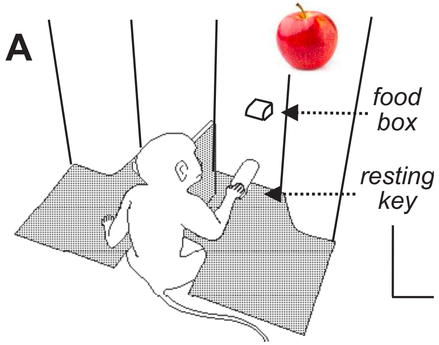
'fight or flight'

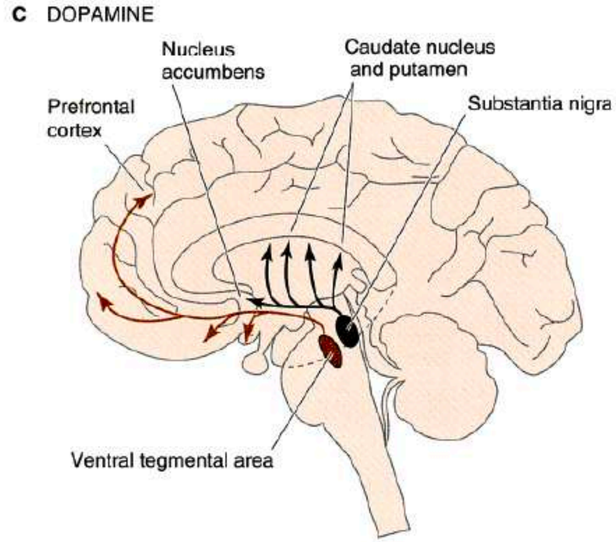


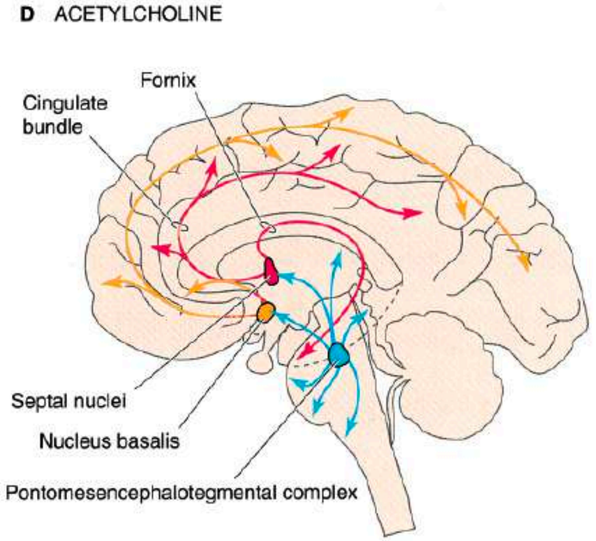


Sleep, Mood, Emotion

Reward, Pleasure





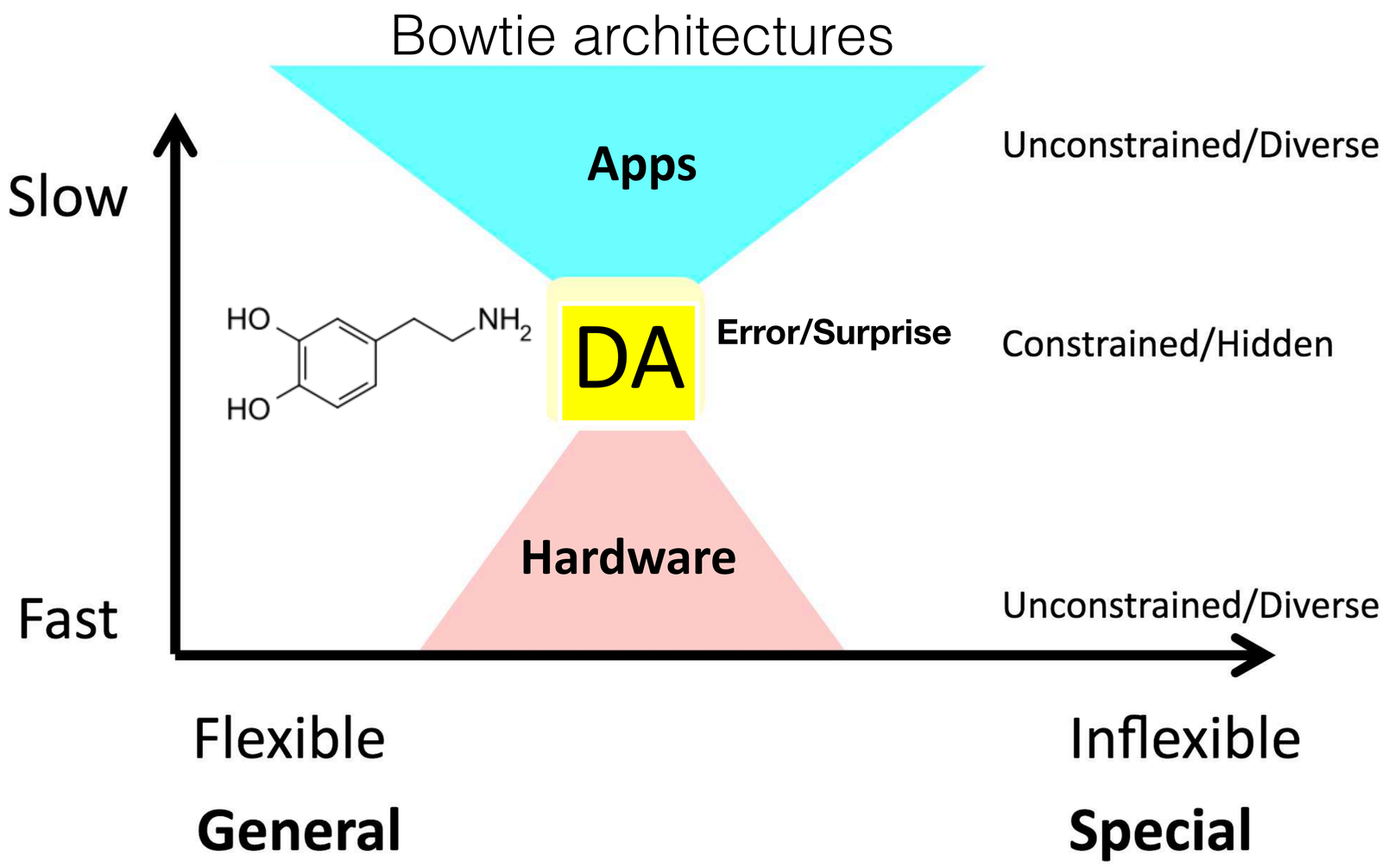


Attention, Emotion

Paul Verschure

(Brain) Architectures provide Constraints that *Deconstrain*

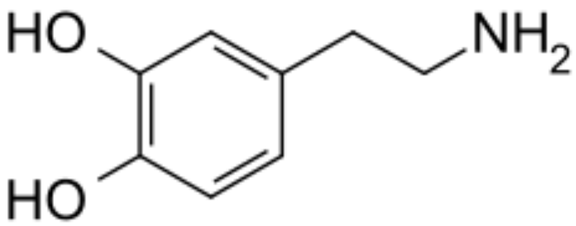
It is NOT about the apps, it is about the operating system - iOS- of the brain



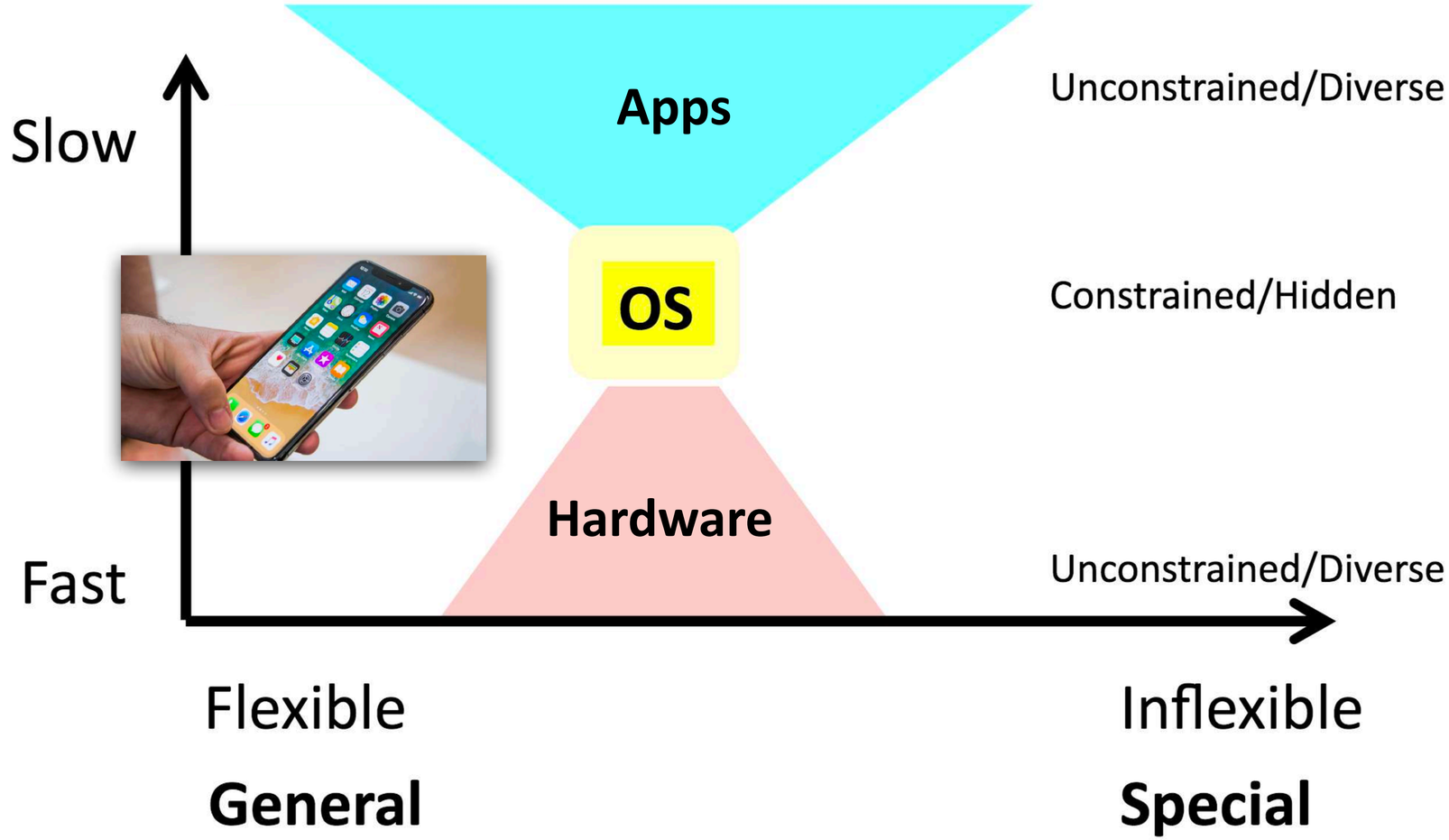
Verschure (2014; 2016) Phil.Tr.Roy.Soc B

(Brain) Architectures comprise **Constraints** that *Deconstrain*

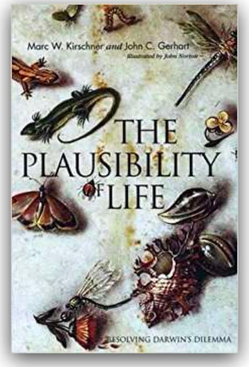
It is NOT about the apps, it is about the operating system - iOS- of the brain



Bowtie architectures



Doyle & Cseste 2011 PNAS



Kirschner & Gerhart 2006

(Brain) Architectures provide Constraints that *Deconstrain*

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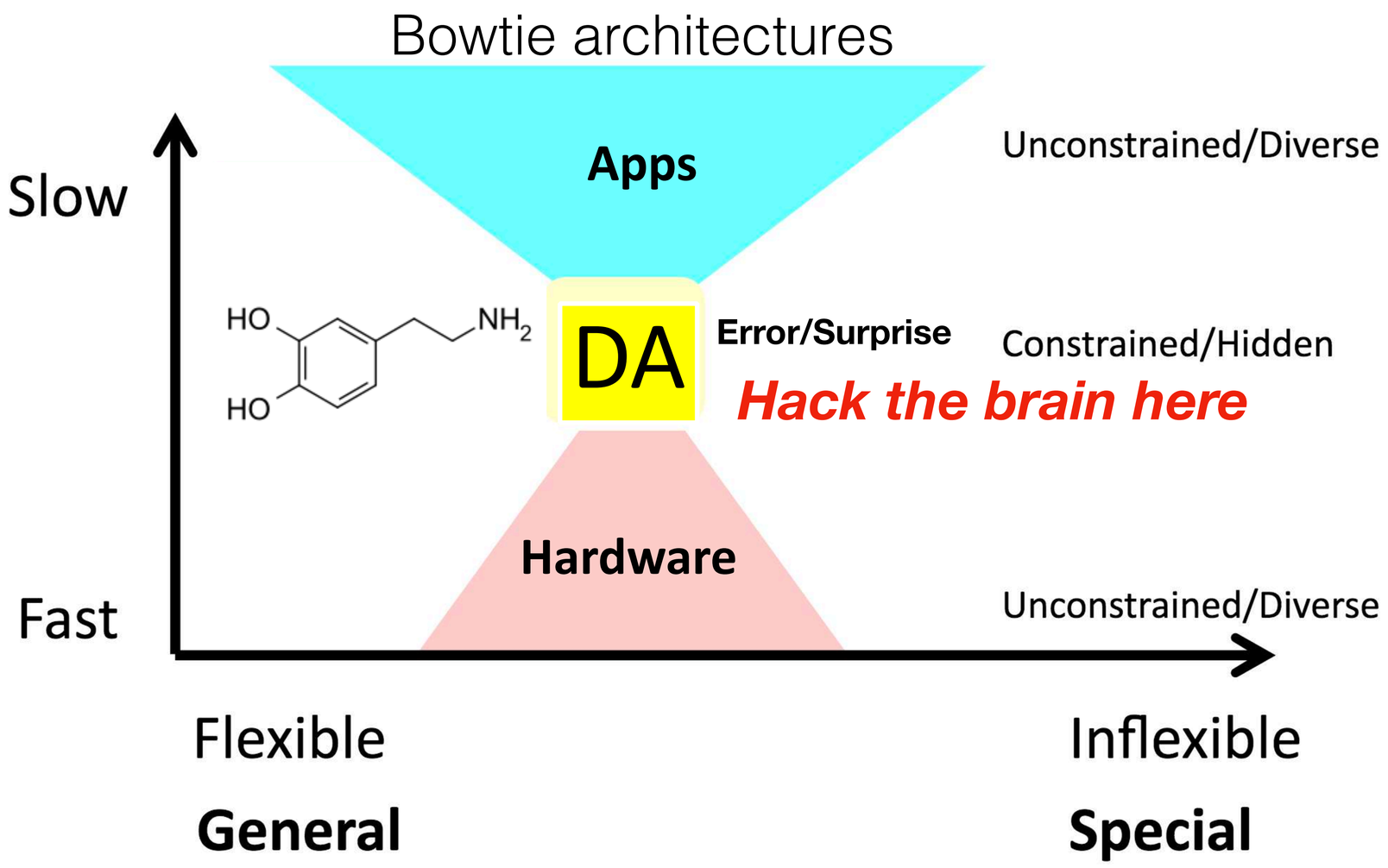
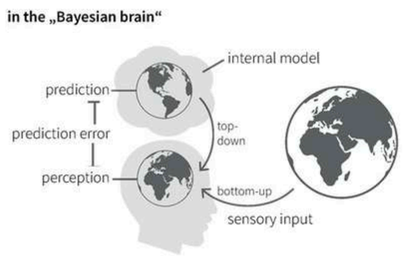
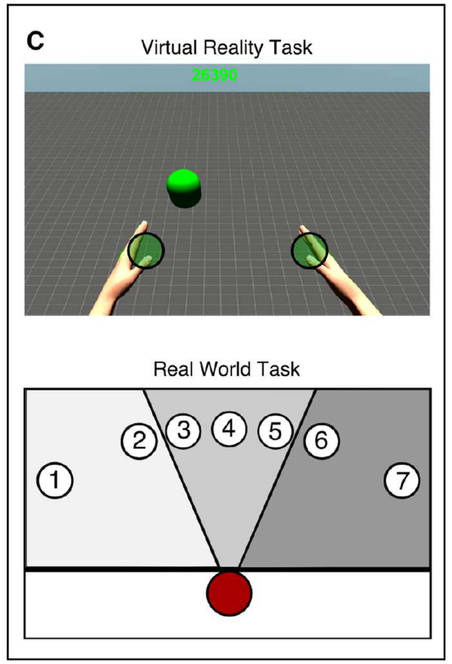
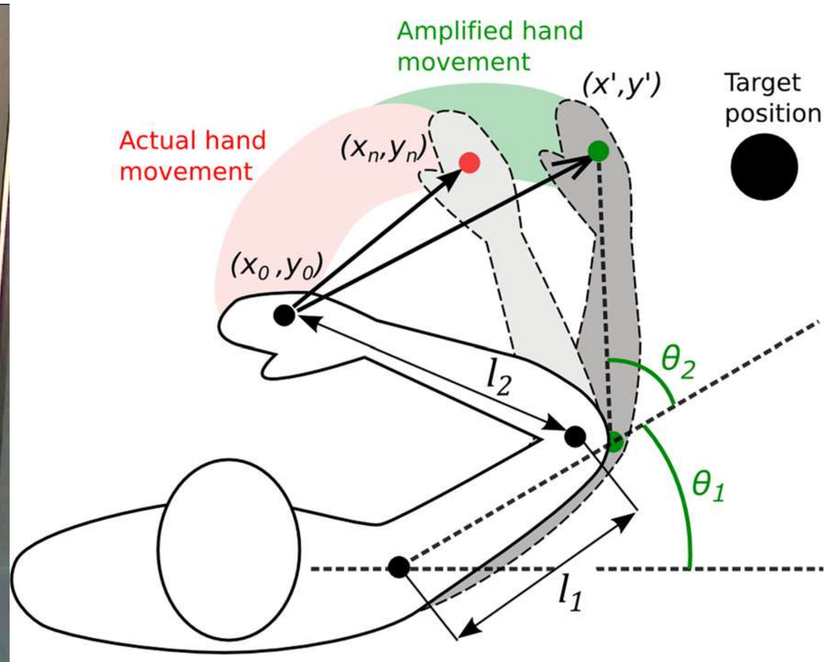


Verschure (2014; 2016) Phil.Tr.Roy.Soc B

Virtual perceptual error reduction: Acquired non-use use case





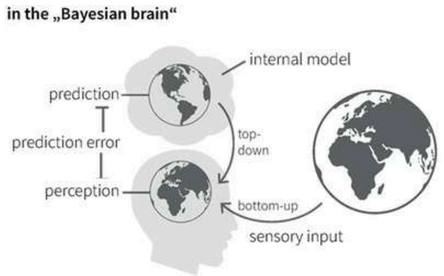


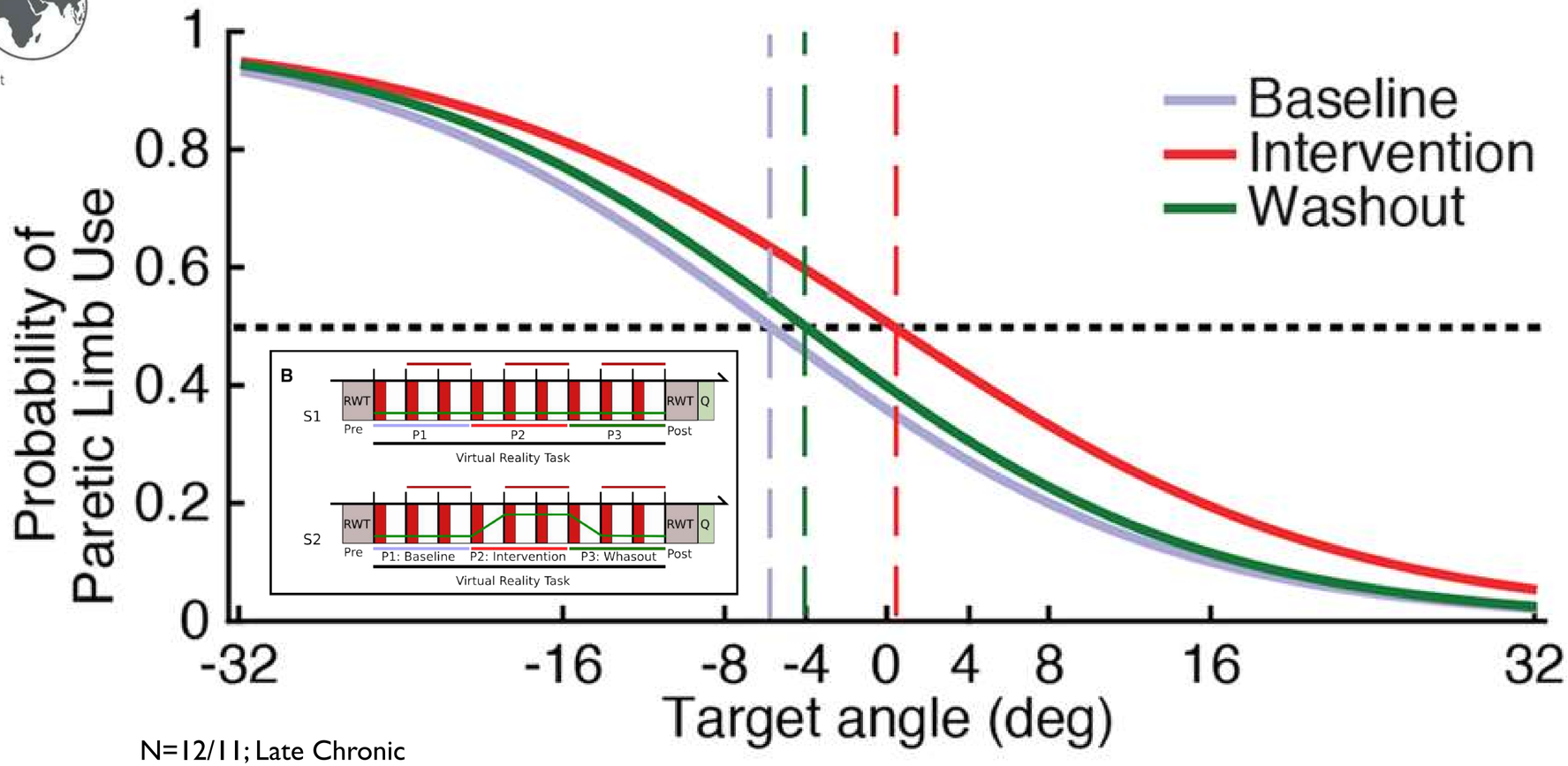
Paretic arm **visual** error minimization

Ballester et al (2014; 2016) ESC; JNER

Hacking the brain's error processing for good in stroke neurorehabilitation

Solving acquired non-use by hacking the brain's error tracking





N=12/11; Late Chronic

Mean days post stroke ~1300

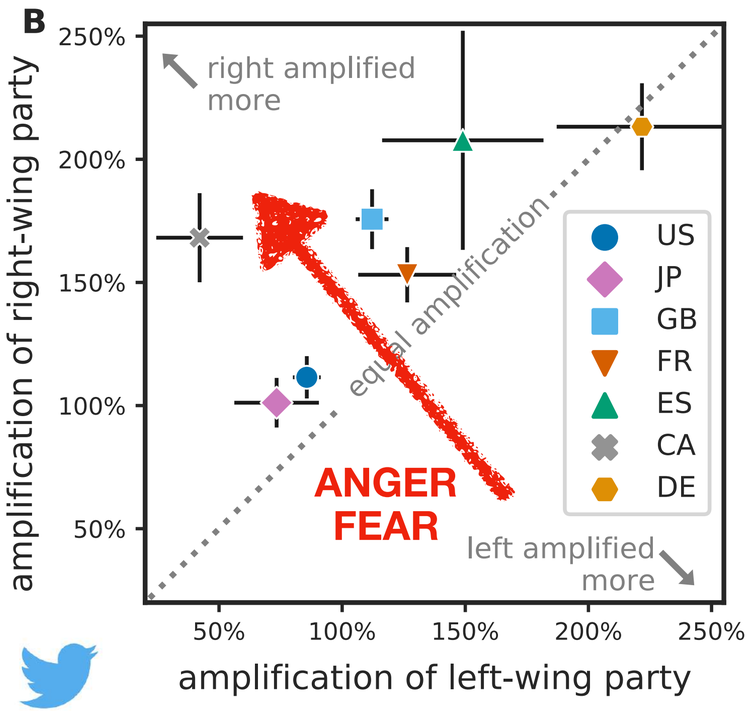
2 sessions of 300 trials each

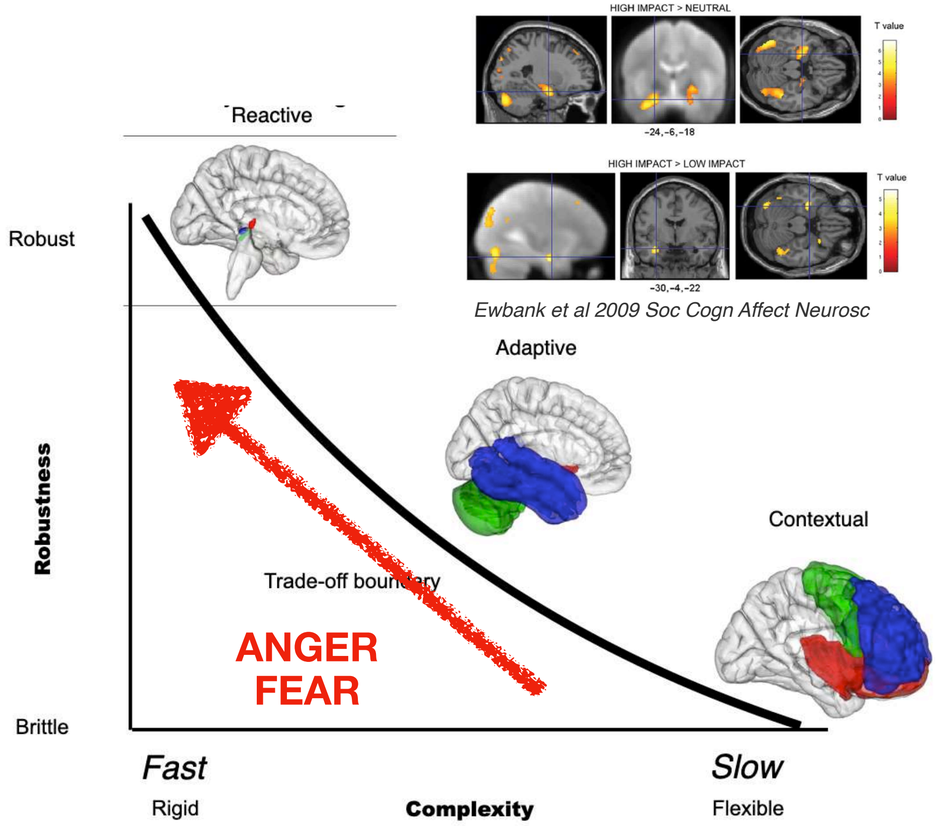
Ballester et al (2014; 2015) ESC; JNER

Hacking the brain's error processing for good in stroke neurorehabilitation

The economy of emotions: attacks the brain's operating system

Bakir & Andrew McStay 2018 Dig Journ.





Ewbank et al 2009 Soc Cogn Affect Neurosc

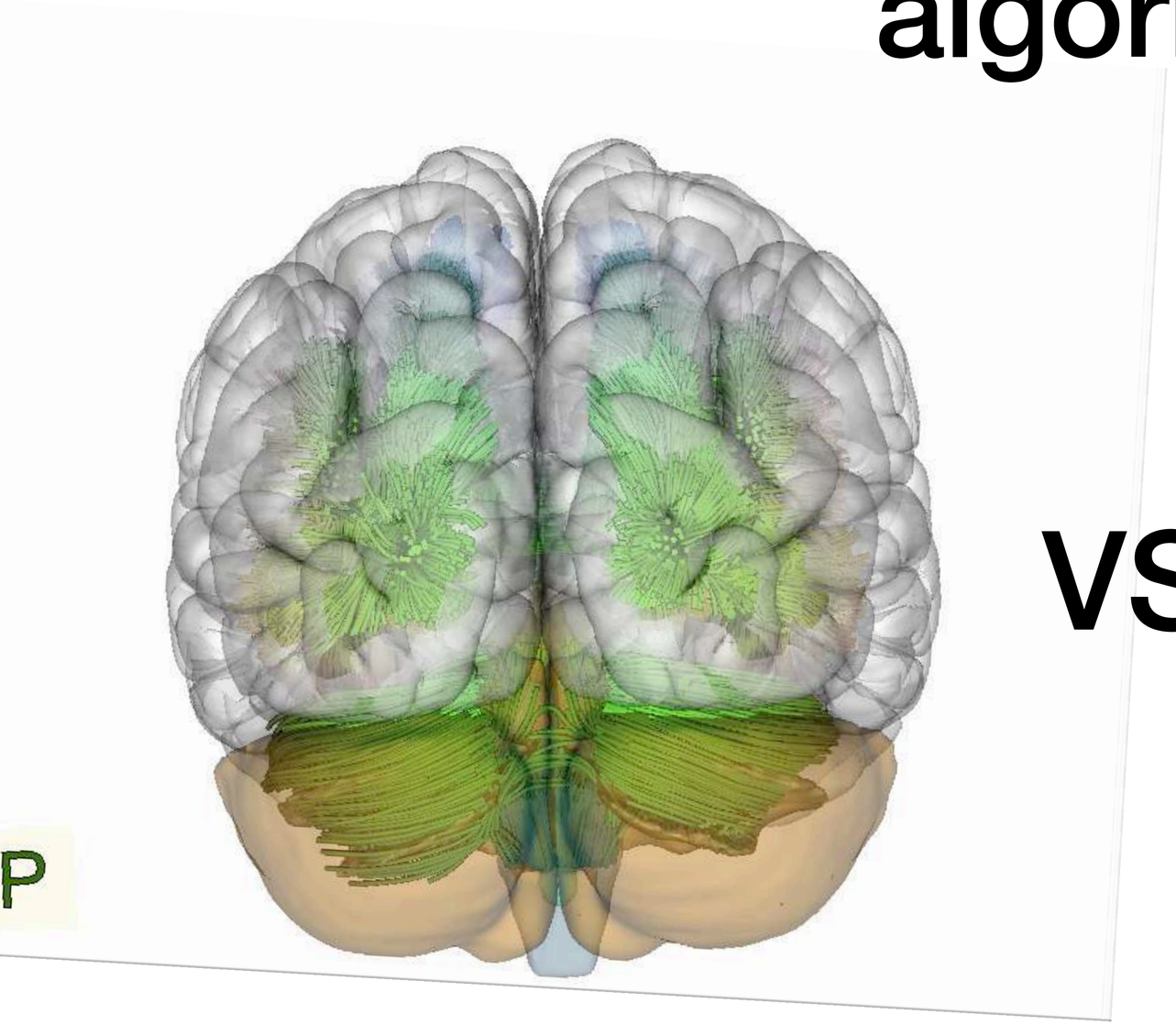
Huszár et al (2022). Algorithmic amplification of politics on Twitter. *PNAS*

Negative emotions decontextualises experience and memory

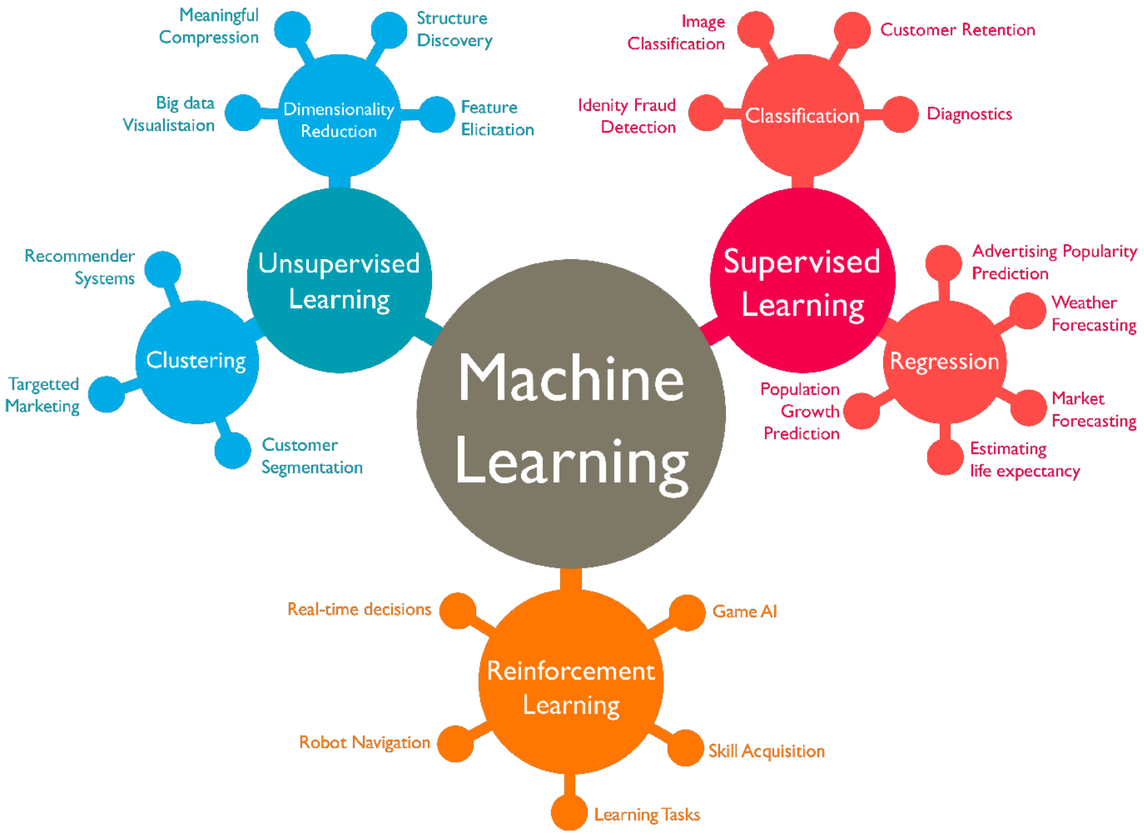
AND

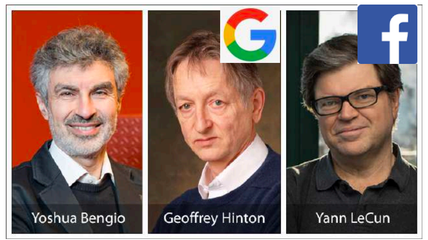
drive (re)action, i.e. clicks

Disinformation: The brain against algorithms

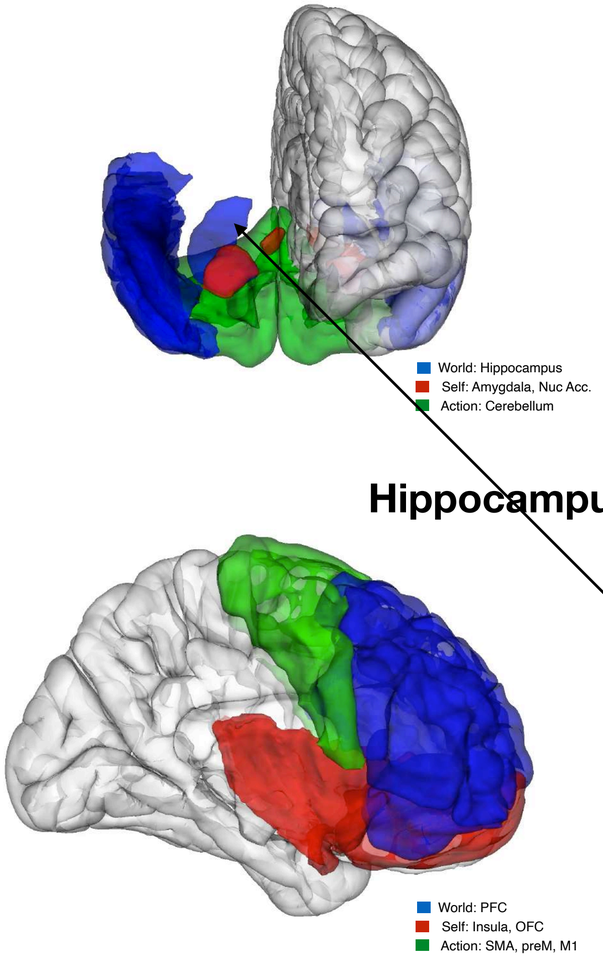


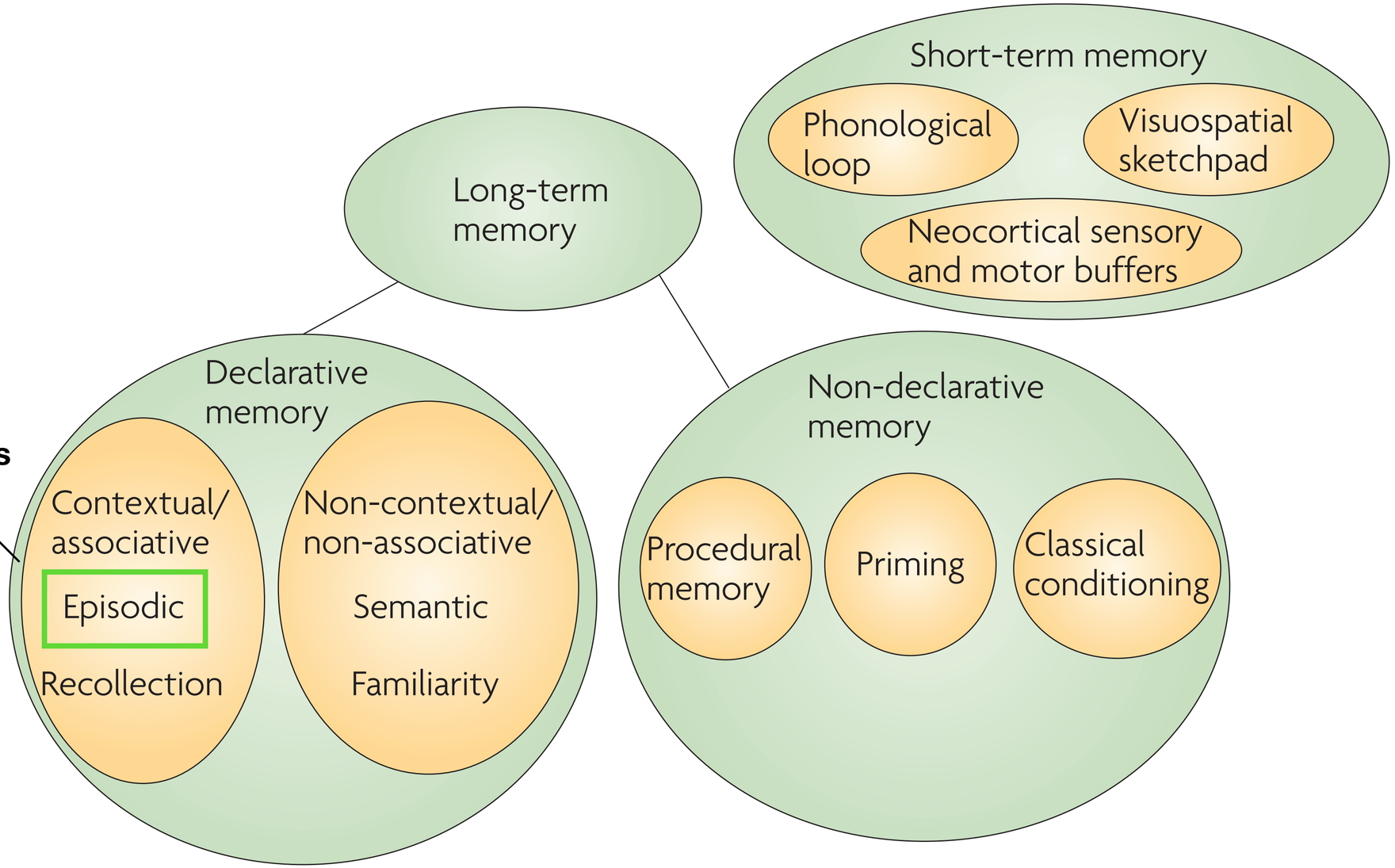
VS





Building resilience

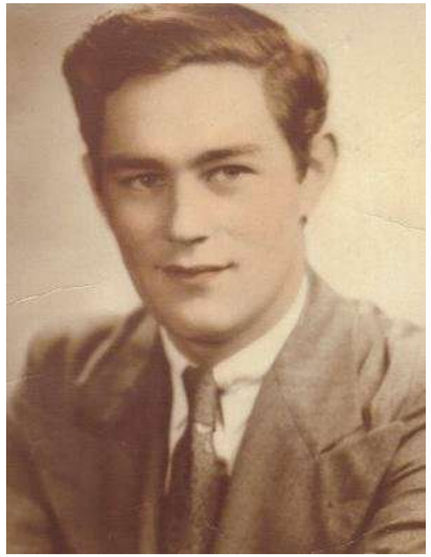




Bird & Burgess 2008 Nat Rev Neurosci

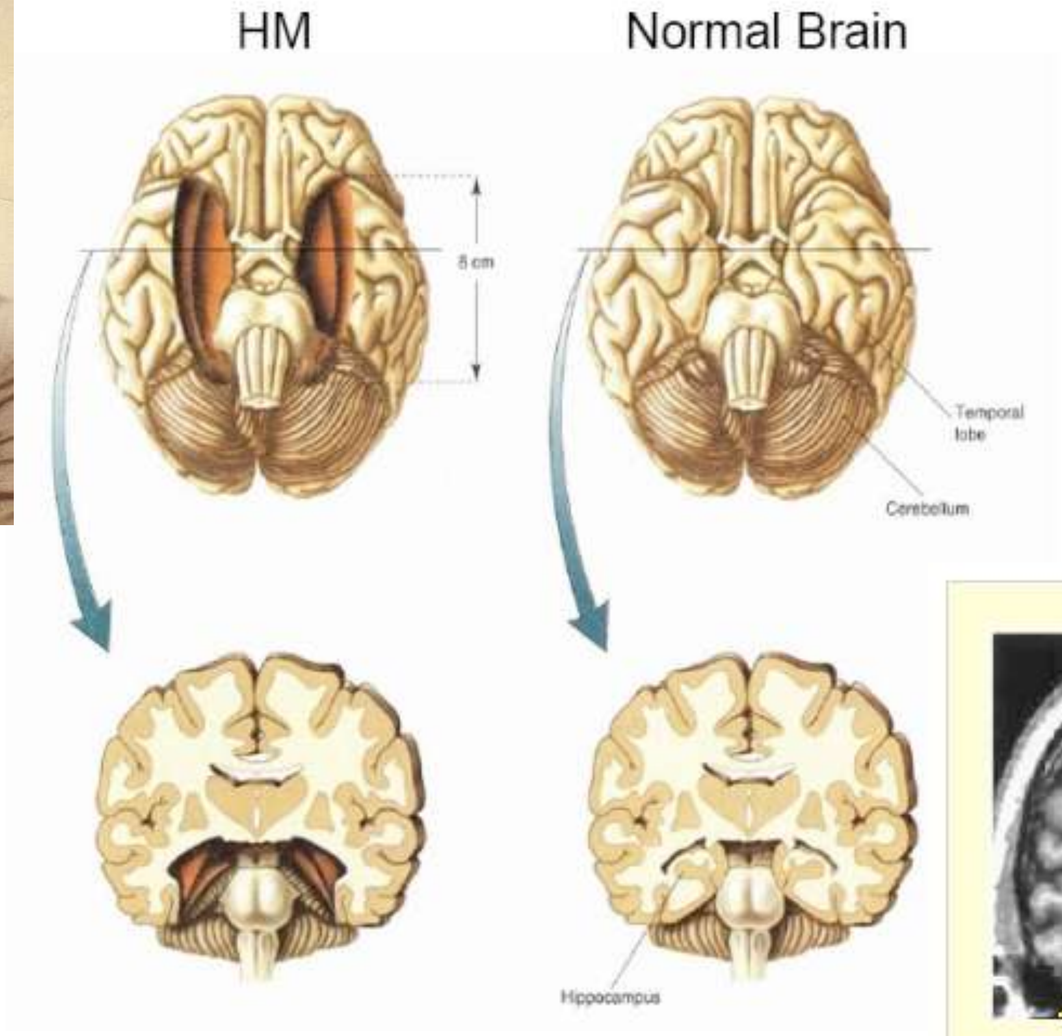
The brain comprises multiple memory systems

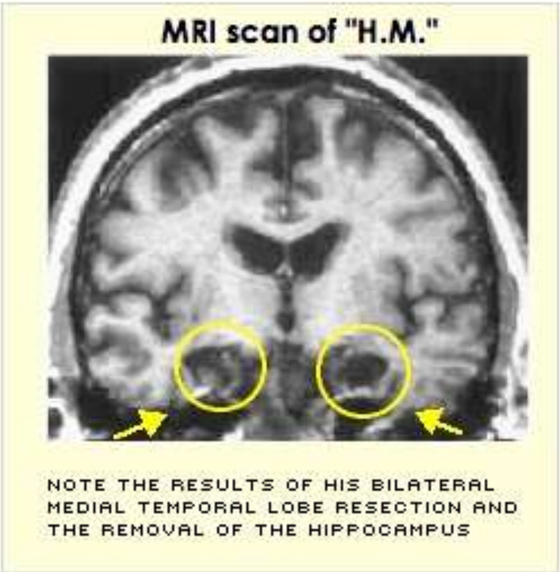
HM and memory deficits



Henry Gustav Molaison

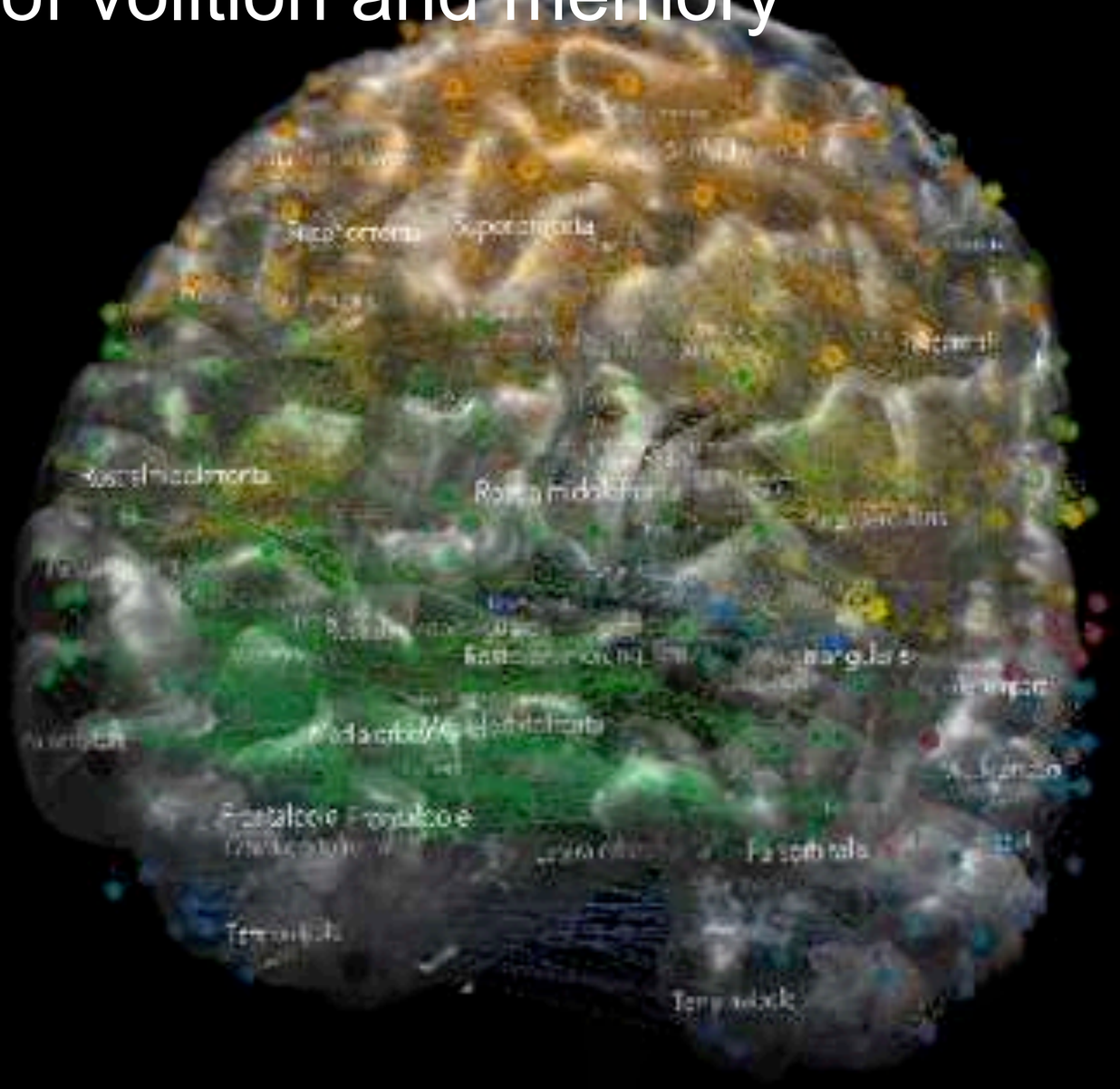
(1926 – 2008)





Hippocampus is critical for episodic-contextual memory

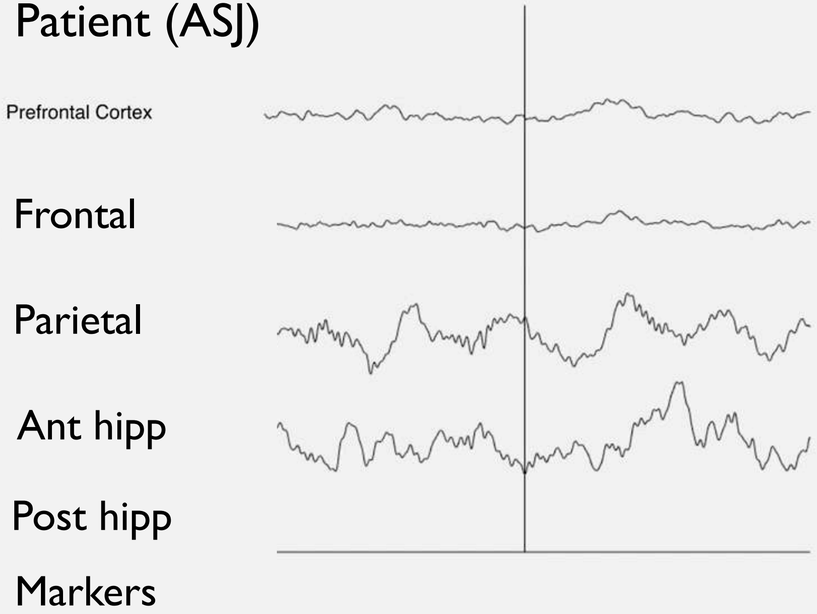
Neurophysiology of volition and memory

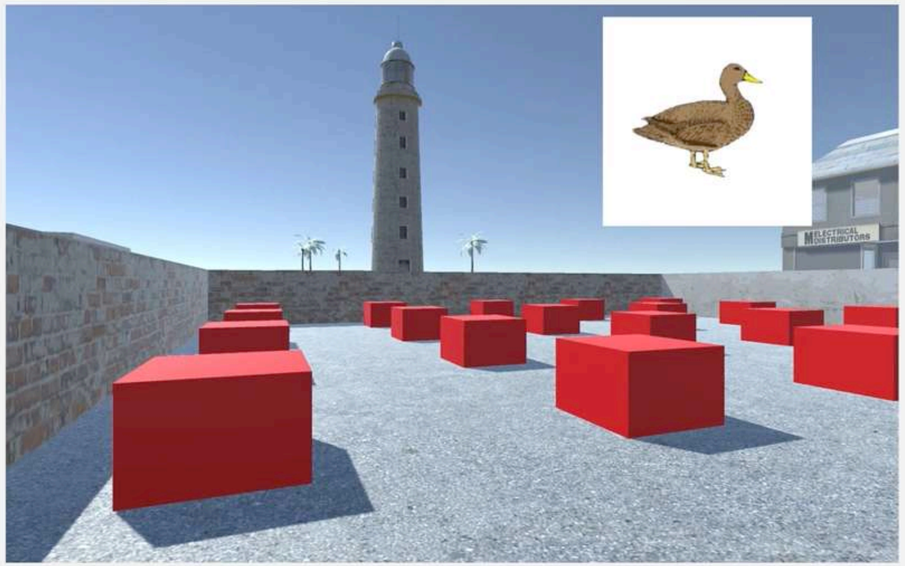


With Rodrigo Rocamora, H del Mar, Barcelona

Volition versus yoked (coercive) control

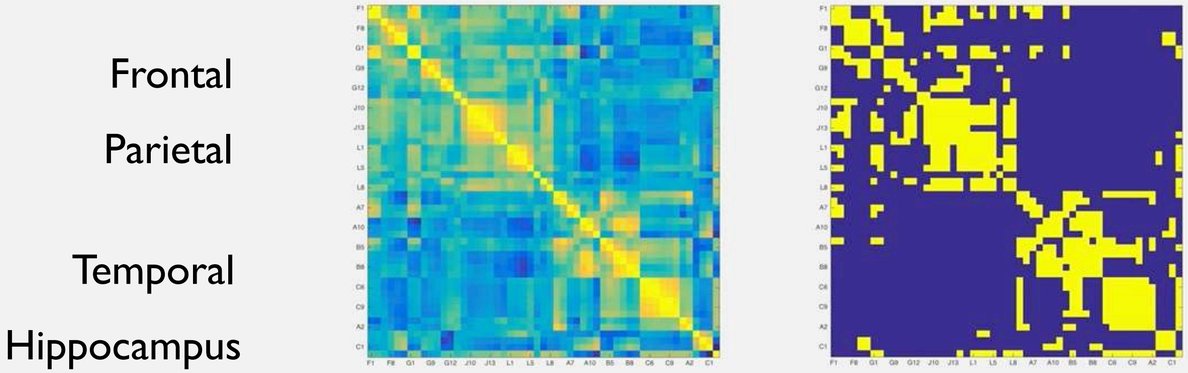
Patient (ASJ)





Freely navigate to the red blocks & remember the image

Spearman's correlations of band pass filtered activity over time (100 ms)

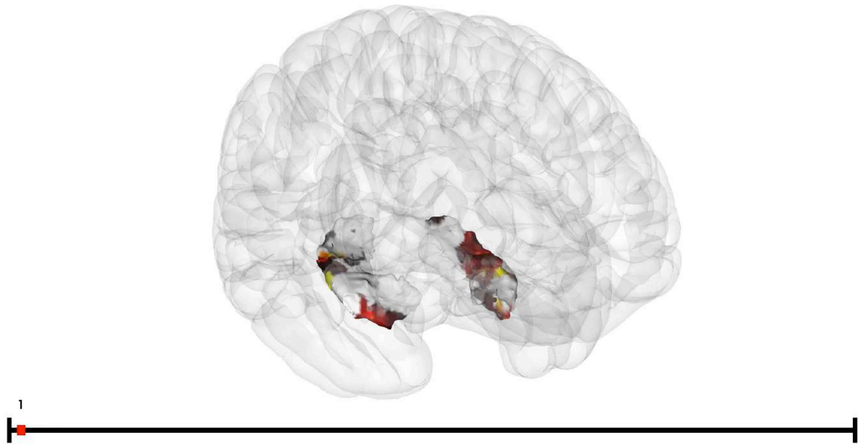


+ correlations

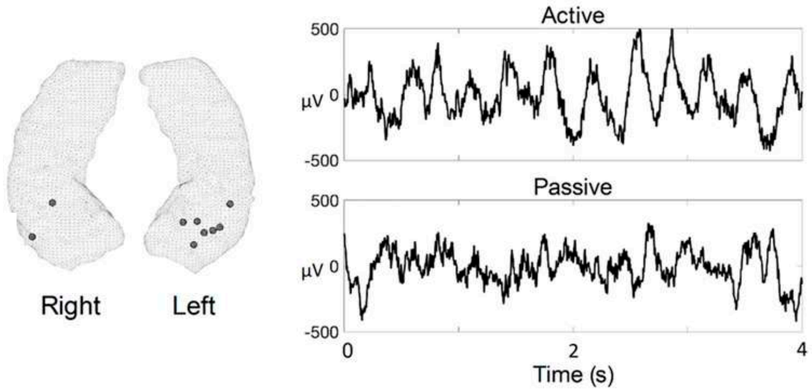
Pacheco et al (2021) PNAS

Volition drives (Theta) Oscillations in the Human Brain

Memory is driven by VOLUNTARY ACTION



brainx3.com



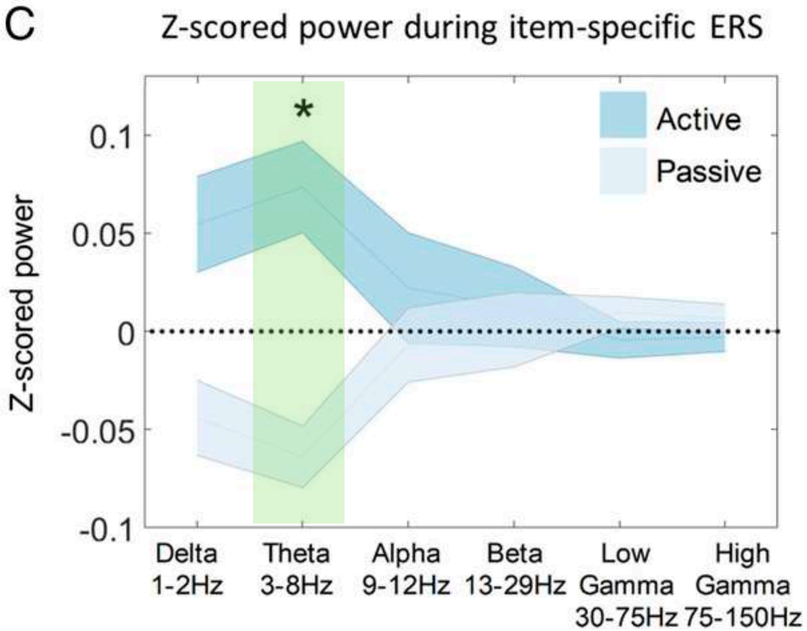
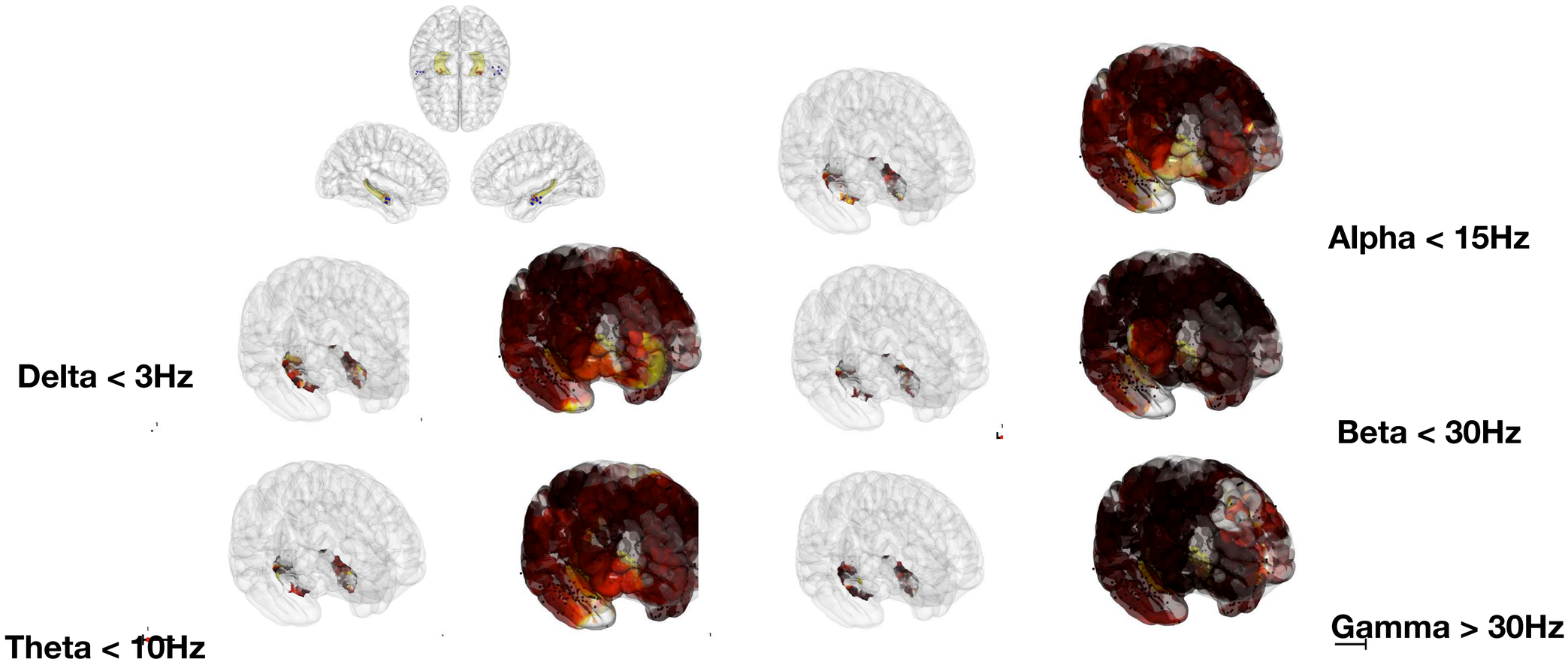


TABLE I. THE FREQUENCY BANDS OF EEG SIGNALS

Waves	Frequency bands (Hz)	Behaviour Trait	Signal Waveform
Delta	0.3 – 4	Deep sleep	
Theta	4 – 8	Deep Meditation	
Alpha	8 – 13	Eyes closed, awake	
Beta	13 – 30	Eyes opened, thinking	
Gamma	30 and above	Unifying consciousness	

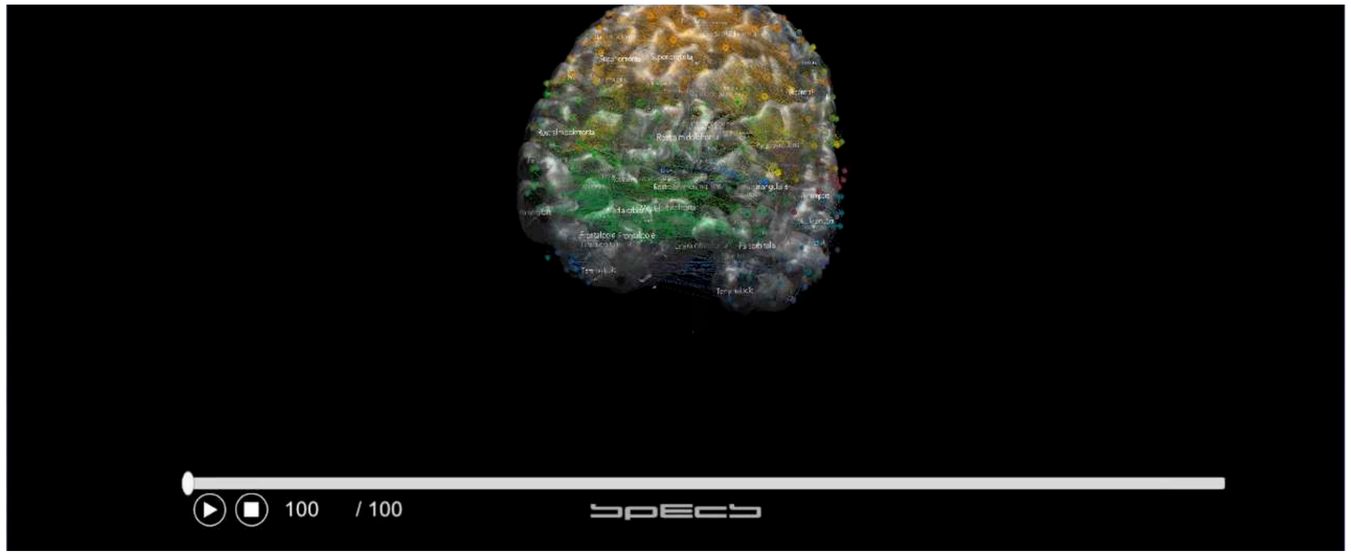
Pacheco et al (2021) PNAS

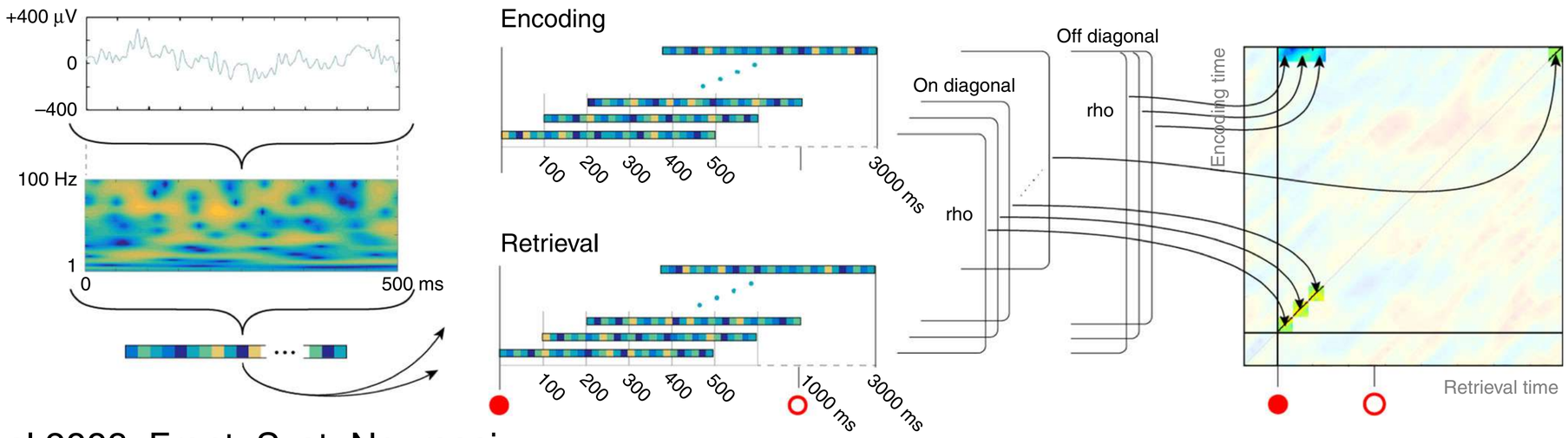
How to decode a complex brain responses?



Pacheco et al 2019 Nat Comm

Reinstatement analysis

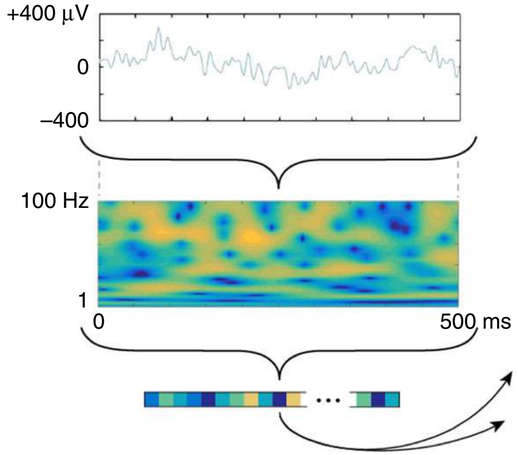




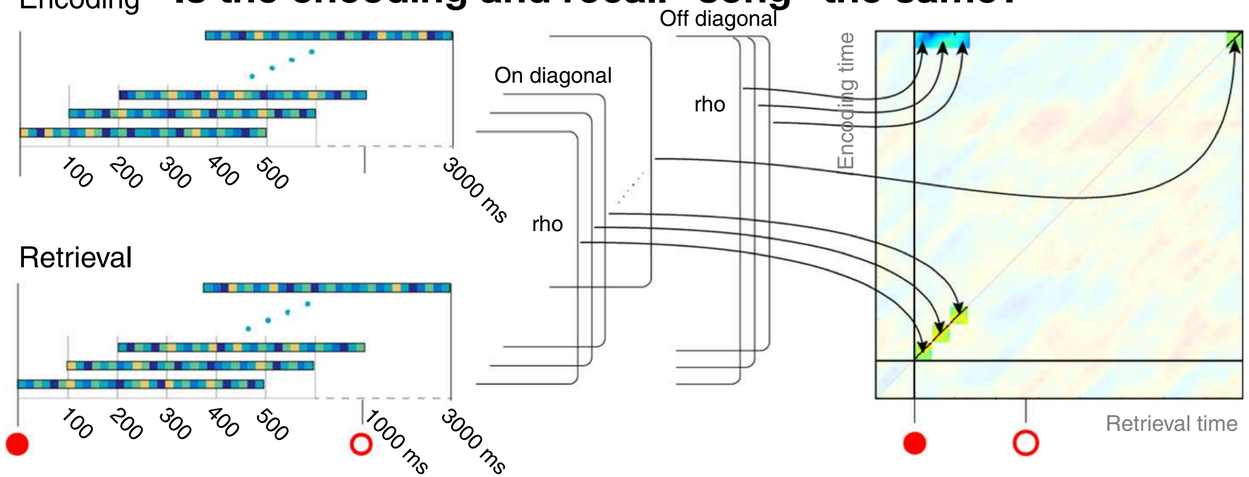
Kriegeskorte, et al 2008 Front. Syst. Neurosci.
Watrous, et al 2015 Curr. Opin. Neurobiol.

Pacheco et al 2019 Nat Comm

Reinstatement analysis: The brain choir



Is the encoding and recall "song" the same?

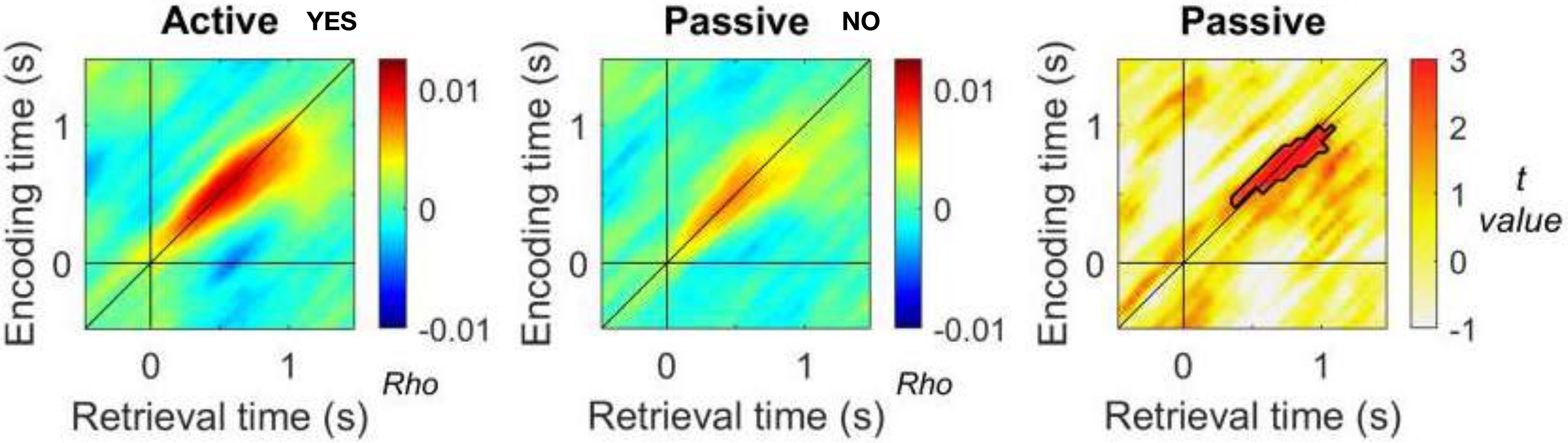


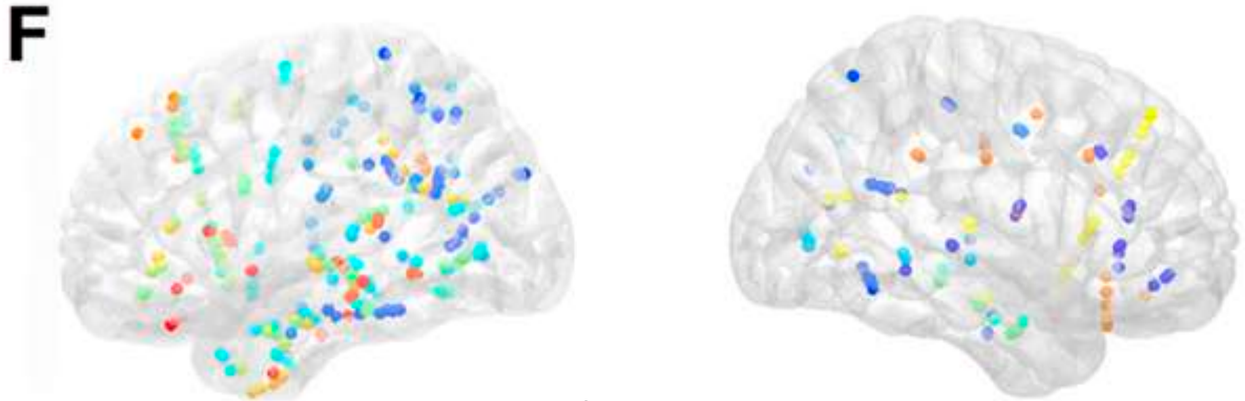
Kriegeskorte, et al 2008 Front. Syst. Neurosci.
Watrous, et al 2015 Curr. Opin. Neurobiol.

Pacheco et al 2019 Nat Comm

The voluntary brain is an integrated contextual system

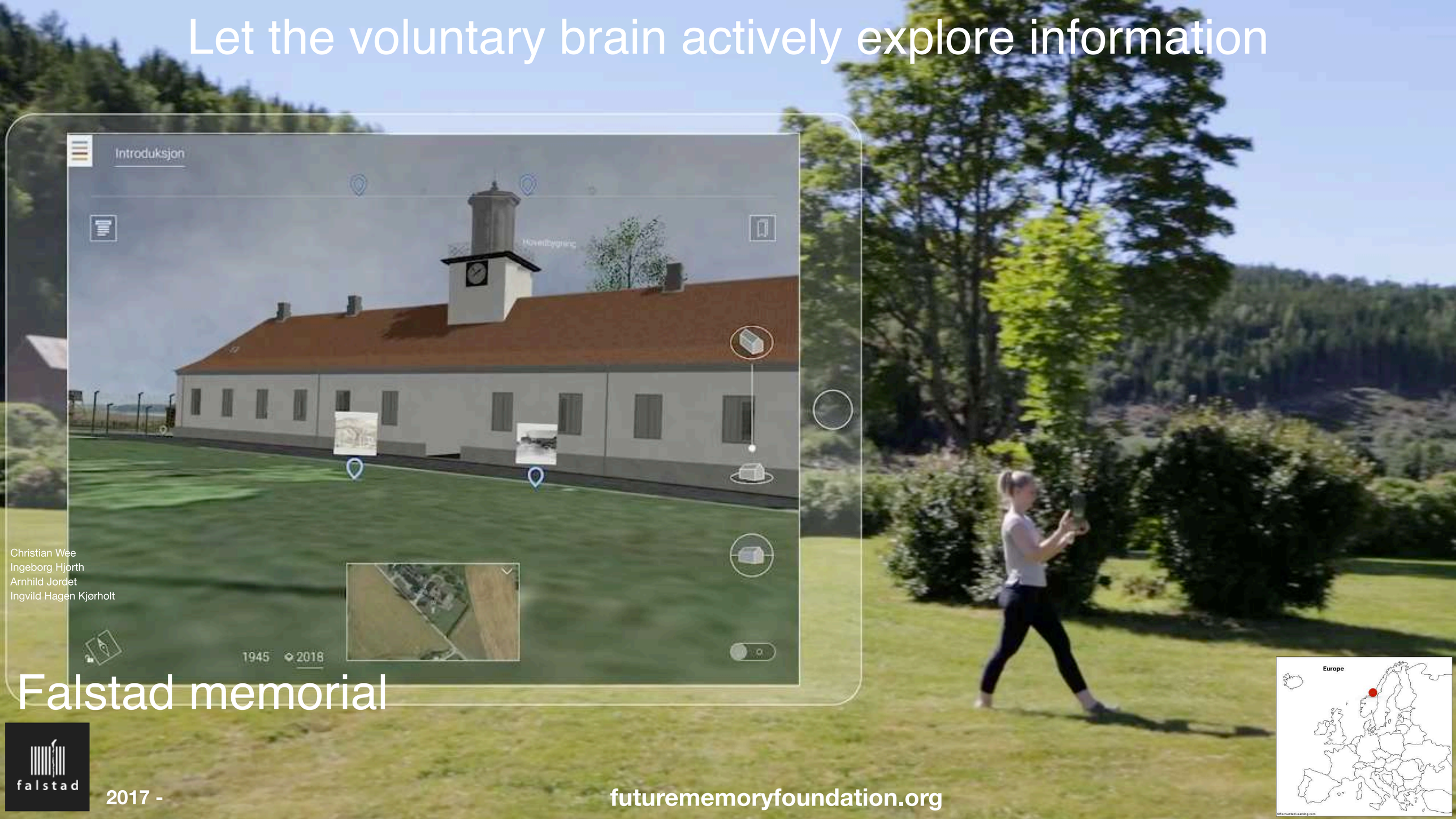
Is the encoding and recall "song" the same?





Pacheco et al (2021) PNAS

Let the voluntary brain actively explore information



Christian Wee
Ingeborg Hjorth
Arnhild Jordet
Ingvild Hagen Kjørholt

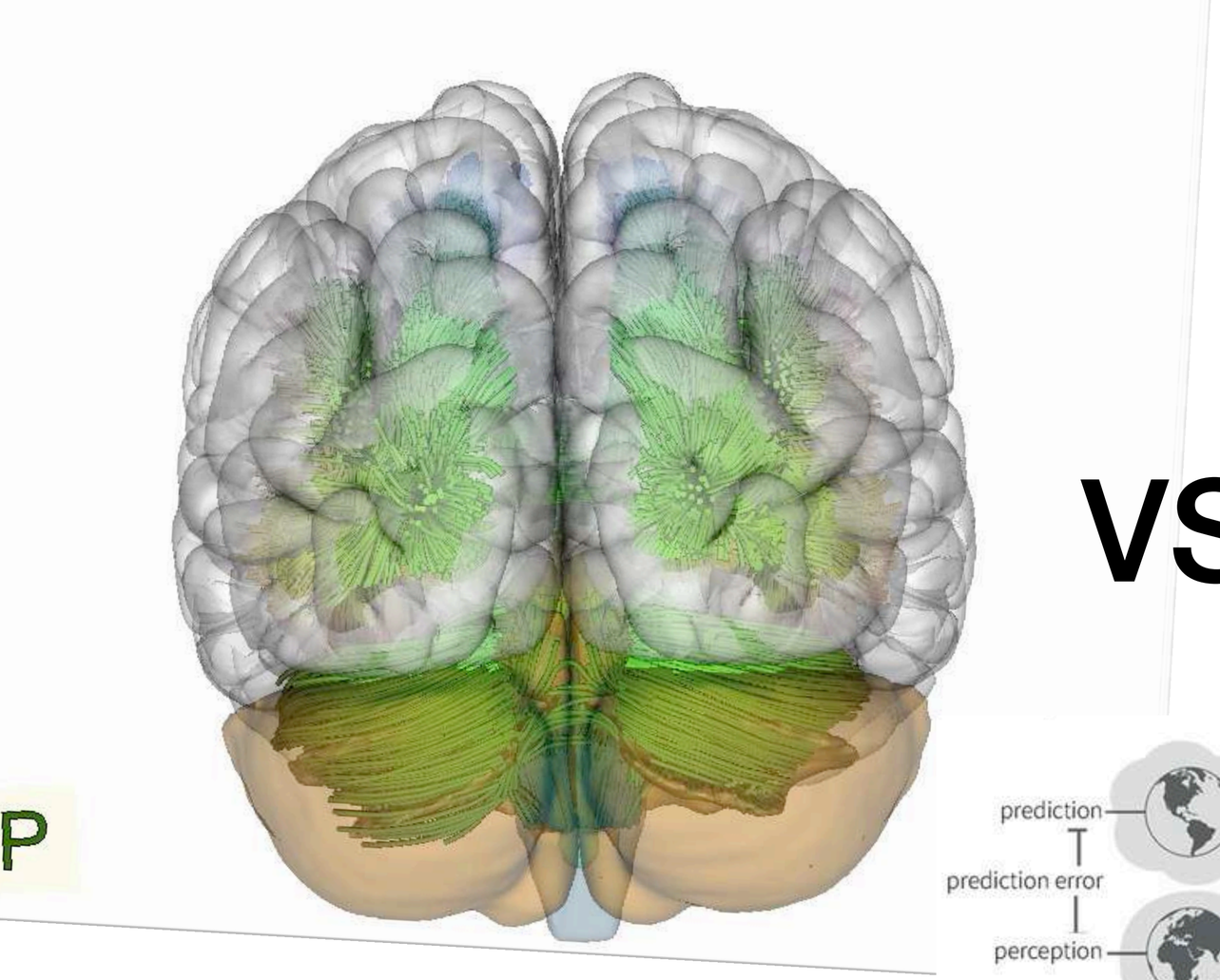
Falstad memorial

falstad

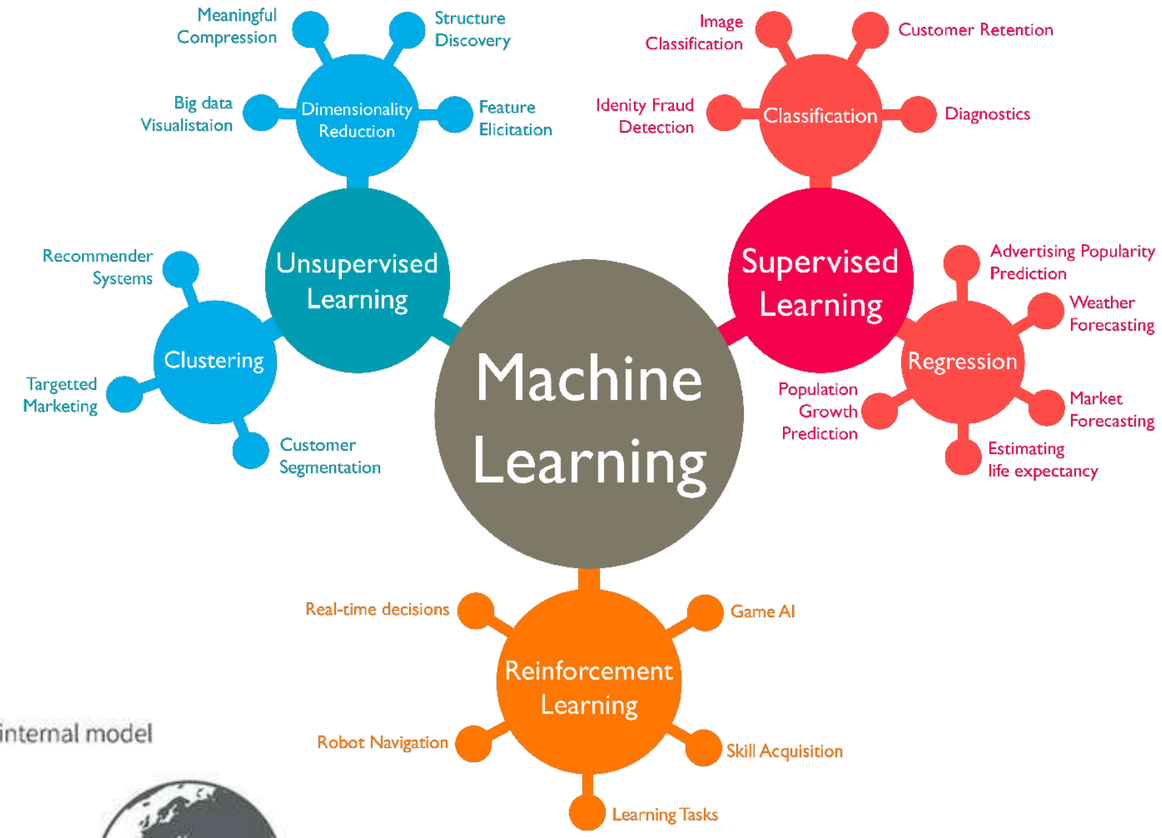
2017 -

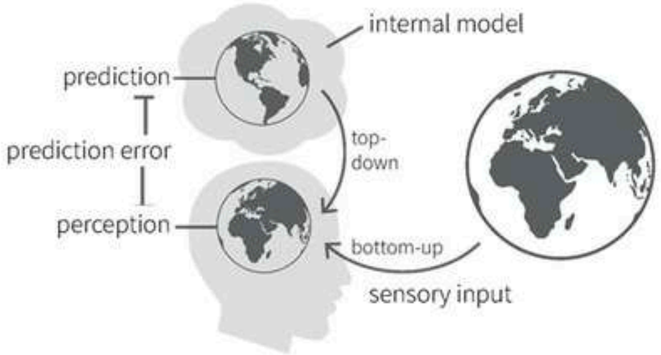
futurememoryfoundation.org

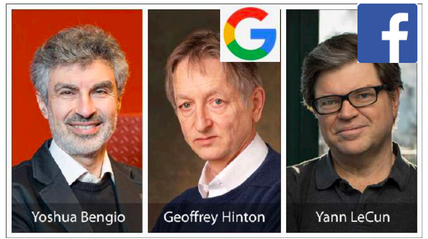
Some observations:
It is not about the humans it is about the algorithms that exploit the operating system of the brain



VS







eodyne.com

specs-lab.com

Some observations

- We need to understand the way the brain processes, mediates and reacts to (dis)information
- Information > **Brain** > Action <……> Information > **Algorithm** > Action
  - We are up against algorithms not humans
- The quest of the “learned ignorati”
- Risk of instrumentalization of the Commons
- Social media algorithms are a mental health risk and must therefore satisfy CEII
  - Self-monitoring is not enough!

CE

Rehabilitation Gaming System

specs

Synthetic, Perceptive, Emotive and Cognitive Systems group

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Established by the European Commission

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Radboud University

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